SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1914.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1914.

GENERAL PHYSICS.

586. *Instrument for Solving Spherical Triangles.* (Eng. News, 71. pp. 180–181, Jan. 22, 1914.)—Describes, with photographs, an instrument called the "mechanical navigator," which solves mechanically, by the setting-off of angles on rotating arcs, all the problems in spherical trigonometry which arise in navigation. By manipulating the instrument a navigator may find in one operation a ship's place at sea from two sights, making allowance for the ship's run. This is equivalent to solving three spherical triangles simultaneously, thus avoiding the use of the method of the Sumner lines, or their treatment by the method of Saint-Hilaire. The result thus found mechanically is claimed to be within 2′ of arc, or less than the theoretical errors of the above methods. A detailed description is given of the method of use in certain cases. A. W.

587. *Micro-balance for Determining Densities of Small Quantities of Gases.* **F. W. Aston.** (Roy. Soc., Proc. Ser. A. 89. pp. 439–446, Jan. 1, 1914.)—A simple form of micro-balance is described, by which the densities of gases may be determined relative to some standard gas, using a null method. The apparatus is similar in principle to the quartz micro-balance of Steele and Grant [Abstract No. 1988 (1909)], subsequently used by Gray and Ramsay [Abstract No. 1768 (1910)] in determining the density of RaEm. This instrument was made with a small quartz bulb fixed to one end of the beam, the weighings being done by altering the pressure of the air in the balance case. By knowing the buoyancy of the bulb and observing the pressure necessary to bring the beam to zero, the weight at the other end of the beam could be calculated. If, however, the bulb is balanced by a fixed counterpoise, the pressure necessary to bring the beam to zero will be a measure of the density of the gas in the balance case. The moving part of the balance is made of fused quartz; it turns upon a simple knife-edge cut on a piece of quartz rod about 0·5 mm. thick. To this rod, a few mm. above the knife-edge, are fused two others of about the same thickness, forming the arms of a beam. To the end of one arm is fused a quartz bulb (volume about 0·3 c.cm.) and to the other a counterpoise made from a piece of rod about 2 mm. thick. The total length is about 5 cm. and the weight of the whole is under 0·2 gm. The balance is designed to be operated at pressures of about 100 mm. of mercury, and by special construction the volume of the balance case was reduced so that only about 0·5 c.cm. of gas is required. The determination of the density can be performed in a few minutes, with an accuracy of 0·1 %. Possibilities of the use of the balance in other fields of research than that for which the apparatus was designed (comparing the densities of specimens of neon) are indicated. A. W.

588. *Gardner's Gyroscope.* (Engineering, 97. p. 229, Feb. 13, 1914.)—Describes the specially free-running gyroscope for use in steering a torpedo. It may be spun by a jet of compressed air directed on to buckets in its periphery. With an initial speed of 4000 revs. per min. the total run may last about 35 mins., the diam. being 3 in. and the mass 2 lbs. E. H. B.

589. *Determination of Level with Mercury Bath.* **A. Broca** and **C. Florian.** (Comptes Rendus, 157. pp. 1044–1047, Dec. 1, 1913.)—In order to avoid the difficulties introduced by the temperature effect on air-bubble levels, a method has been developed of utilising a mercury surface treated to subdue the small oscillations due to vibration. Various viscous liquids were tried, but the best combination for bearing transport from place to place was found to be glycerine over the mercury surface, enclosed in an exhausted box. For work at low temperatures it is recommended to add a little absolute alcohol to the glycerine. The top of the box is made of plane-parallel glass, the under surface being in contact with the glycerine. To the upper surface of this plate is cemented an objective furnished with an auto-collimating eyepiece. The deviations observed in the focal plane are then multiplied by the index of refraction of the glycerine. C. P. B.

590. *Density of Some Metals in the Liquid State.* **P. Pascal** and **A. Jouniaux.** (Comptes Rendus, 158. pp. 414–416, Feb. 9, 1914.)—The authors have applied the use of a quartz float to the determination of the density of fluid metals up to 1300° C. At the fusion points of the respective metals the following values were obtained :—

Tin	6·98	(232° C.)	Antimony	6·55	(631° C.)
Lead	10·875	(327° C)	Aluminium	2·41	(658° C.)
Zinc	6·92	(418° C.)	Copper	8·40	(1083° C.)

For these metals equations have been worked out showing the relationship between specific volumes and temperatures. The specific volume curve for tin shows a marked inflection at 620° C., showing a rapid increase in dilatation at high temperatures. This appears to be a case of dynamic allotropy, similar to that observed in a number of other substances, notably sulphur, at low temperatures. There is a certain analogy between the shapes of the dilatation curves before and after fusion. F. C. A. H. L.

591. *Acoustical Estimation of Density of Gas or Liquid.* **A. Kalähne.** (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 81–92, Jan. 30, 1914.)—This method depends upon the fact that a solid moving in a fluid is loaded by a portion of that fluid. Hence, if the solid is in vibration, its period is slightly increased by this loading. An aluminium tube is set in lateral vibration of the fundamental mode having two nodes at which it is held by screw points. Then,

using the apparatus with air and other gases in turn, and noting the changes in frequency (say, by beats with a like apparatus in the standard state), the dependence of frequency on the density of the gas is found. Hence the density may be inferred in any like case. E. H. B.

593. *Designation of Units for which Equations Hold.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 97–99, Jan. 30, 1914.)—Recommends that in an equation which holds between the numerical values of quantities, the units for each factor should be shown as subscripts. Thus $f_{m^2} = l_m b_m$ for the area f in square metres of a rectangle of length and breadth l and b metres. Or, again, Young's modulus in special units may be shown by—

$$\mathrm{E}_{\mathrm{kg.wt/mm.}^2} = \frac{l_{\mathrm{cm.}} \ \mathrm{P}_{\mathrm{kg.wt./mm.}^2}}{\lambda_{\mathrm{cm.}} \ q_{\mathrm{mm.}^2}}.$$

E. H. B.

593. *Relativity Theory.* **S. Mohorovičić.** (Phys. Zeitschr. 14. pp. 988–989, Oct. 15, 1913.)—Illustrates the conclusion "that the sum of two velocities approaching the velocity of light never exceeds the velocity of light" by means of Lobatchevski's non-Euclidian geometry of hyperbolic planes. E. E. F.

594. *Deviation of Falling Weights.* **G. Gianfranceschi.** (Accad. Lincei, Atti, 22. pp. 561–568, Dec. 7, 1913.)—Allows a weight to fall 32 m. in an arrangement resembling Atwood's machine. The weight has a steel point which pricks a cardboard target. The mean easterly deviation due to the earth's rotation is 1·866 mm. There is also a small northerly deviation amounting to 0·033 mm. By Gauss's theory the former should be 2·081 mm., and the latter should be zero. In spite of these discrepancies Gauss's theory corresponds better with observed values than the theories of Woodward or Hagen. E. E. F.

595. *Canonical Relations in General Dynamics.* **A. Gray.** (Phil. Mag. 27. pp. 22–43, Jan., 1914.)—An analytical treatment of the subject in terms of generalised co-ordinates. For details the original should be consulted as its nature renders its unsuitable for abstraction. E. H. B.

596. *Experimental Determinations of the Viscosity and Density of Molten Metals and Alloys.* **R. Arpi.** (Int. Zeitschr. Metallog. 5. pp. 142–168, Jan., 1914.)—Determinations of the viscosities of fused metals, which had previously been carried out only with mercury, have been made on cadmium, tin, lead, and bismuth, and on Pb-Sn and Pb-Bi alloys at temperatures ranging from the melting-points to 550°. Poiseuille's method was followed, and the viscosity vessel, which was of quartz, was calibrated by means of mercury; hydrogen containing methyl alcohol was found to give a suitable reducing atmosphere. The viscosities of the metals investigated are of the same order of magnitude, and are in the same order as the melting-points. With Cd, Hg, Sn, and Pb the fall in the viscosity with rise of temperature increases in greater proportion than the value of η, but in the case of Bi the fall is relatively less. The viscosities of the fused Pb-Sn alloys are somewhat smaller than would be the case if the law of mixtures held rigorously, and the same holds with the lead-Bi alloys, for which the discrepancy is more marked at low temperatures. The temperature-coefficient of the viscosity is extremely small for the Pb-Bi alloys, and with the higher concentrations of Bi appears to be even lower than that of pure Bi. The

specific gravities of the above metals were also investigated at different temperatures; the values found for the alloys are smaller, although scarcely appreciably so, than those calculated from the law of mixtures. T. H. P.

597. *Edge-angle and Spreading of Liquids on Solids.* **A. Pockels.** (Phys. Zeitschr. 15. pp. 39–46, Jan. 1, 1914.)—In measuring the edge-angle of a liquid on a solid, the utmost importance attaches to the cleanliness of the solid surface, and instructions are given for attaining this. In order to test if the surface is clean or contaminated by fatty or resinous substances, it is dipped into a freshly formed water surface previously dusted over with lycopodium, charcoal, or talc; the floating particles will be repelled and a dust-free zone formed round the surface, if the latter is in the slightest degree dirty. The edge-angle formed by a liquid spreading out on a solid plate and that formed when it is spread out by means of a wire and then allowed to draw together are virtually identical with certain liquids, *e.g.* benzene; the drop then slides on the solid in the same way as does mercury on glass. But with other liquids, such as water and glycerine, a marked difference is observed in the behaviour on spreading and on drawing together; these liquids adhere or cleave to the solid surface. Some of the results of the numerous measurements made with both clean and dirty surfaces are as follows. With water on glass, the edge-angle on contraction of the drop is zero, so that clean glass is wetted by water; the same is the case with water on Pt, and with glycerol on glass or Pt. Alcohol, oil of turpentine, and petroleum spread out on glass or Pt to an unlimited extent to form coloured films. With benzene, ether, or carbon disulphide, the edge-angle very quickly assumes its definite value, which is approximately the same when produced in either way; the drops slide on the surfaces without wetting them. In the case of various oils and oleic acid the cleanliness of the surface is of little moment; but the removal of fatty acids from oil renders the latter more mobile, so that the drop may be slid slowly over the surface, whereas unpurified oil adheres tightly. With surfaces which have not been cleaned by heating, edge-angles are exhibited by many liquids not showing them on clean surfaces. It may be assumed that, besides the liquids examined by the author, many other liquids, especially organic substances, form edge-angles, and these should be taken account of in measuring surface tensions by means of capillary rise. Experiments were made also with strips of copper and zinc, which cannot be cleaned by heating, and were consequently filed with a file frequently used beforehand on the same metal; the results are rendered slightly indefinite by the file-marks, any polishing being inadmissible. Freshly-filed zinc and copper are wetted by water, and the same happens after some hours, while, as with heated Pt, the edge-angle formed on spreading increases rapidly with the time. Smooth fractures of different coals were also examined.

The results obtained are tabulated, and various theoretical consequences considered. T. H. P.

598. *Spontaneous Alteration of Liquid Surfaces.* **C. Cloarec.** (Comptes Rendus, 158. pp. 482–484, Feb. 16, 1914.)—By the method of Duclaux the variations of the surface tension of a liquid can be followed by counting the number, N, of drops furnished by a volume V of that liquid. Suitably modified, this method can be employed for studying the properties of the superficial layers of liquids. By this means the following results have been obtained. When water is left in an uncovered vessel the number N remains constant for the first 8 hours, then it decreases gradually, until at the end of about 50

hours a value is reached which no longer varies with the time. This is explained by the fact that the effect of contact with air is to cover the surface of the water with a kind of membrane the thickness of which increases with the time. When the thickness of this membrane is sufficient to mask completely the action of the subadjacent water, the corresponding value of N is a characteristic of the new superficial layer and is no longer modified by an increase in the thickness of this membrane. With a salt solution N varies from one experiment to the next, indicating a rapid spontaneous alteration of the surface layer. The principal cause of this appears to be of internal origin. If increasing quantities of some oil, such as olive oil, be placed on the surface of water, and the variations of N with the thickness of the layer of oil be represented graphically, a curve is obtained similar to that obtained with the salt solution. The spontaneous alteration of liquid surfaces is also found to be so much the greater and more rapid the smaller the surface. A. E. G.

599. *Phenomena of Fluid Motion.* **W. S. Franklin.** (Frank. Inst., Journ. 177. pp. 23–33, Jan., 1914.)—Discusses the apparent attraction of a pair of balls, hanging side by side, when a jet of air is blown between them; the explanation being that the air-pressure is less where the speed is greater, on Bernoulli's principle. On the same principle a ball or a file handle may be supported by an air-jet. The swerving flight of a ball which spins as it passes through the air is also discussed, the swerve being towards the side to which the leading part of the ball is turning. This again follows from the same principle, as is easily seen if the ball be imagined still and the air blowing past it. Then the air speed is *less* where it meets the *advancing* side of the spinning ball. Accordingly the pressure is greater, and the ball swerves as stated.

E. H. B.

600. *Efflux from a Vessel Perforated in the Base.* **U. Cisotti.** (Accad. Lincei, Atti, 22. pp. 473–478, Nov. 23, 1913.)—The author considers a rectangular vertical vessel of width Ω, with a very small orifice in the centre of the base, a constant efflux, q, of liquid occurring. It is shown analytically that the surface of the liquid falls horizontally with constant velocity, q/Ω, until its distance from the base of the vessel is sensibly equal to Ω. Near the orifice the lines of flow are virtually tangent curves, while in the particular case where the vessel is infinitely wide they take the form of rays converging to the orifice. T. H. P.

601. *Motion of Long Air-bubbles in a Vertical Tube.* **A. H. Gibson.** (Phil. Mag. 26. pp. 952–965, Dec., 1913.)—The motion of an air-bubble rising, under gravity, through the liquid in a vertical tube depends largely on its dimensions, both absolute and relative to those of the tube. With a very small bubble the form is approximately spherical and the motion steady, but as the size is increased the shape changes, becoming more and more contracted in a vertical direction, while the curvature of the lower surface becomes much less than that of the upper. Tubes of moderate dimensions accentuate these changes, and when the bubble diam. is between ¼ and ⅓ that of the tube very irregular motion ensues, for not only does the bubble zigzag across the tube from side to side, but violent oscillations take place about a horizontal axis, showing the periodic variation of the magnitude and distribution of the pressure on its lower face, due to eddy formations in its rear. With further increase in size, the irregularities diminish until, when the diam. is about 0·75 times that of the tube, the bubble begins to adopt a more or less cylindrical

form with an ogival head and flat stern, and the motion becomes steady. Any further increase in volume is mainly effective in increasing the length of the cylindrical portion of the body, the form of the head remaining sensibly unchanged, and the mean diam., although increasing with length, not altering greatly. The bubble body is not actually of the same diam. throughout, but gradually increases to a maximum at its lower extremity. If the tube bore exceeds about 1 cm., such a bubble shows a beautiful series of well-defined waves or ripples around the lower portion of its barrel. These are stationary relative to the surface of the bubble, and when the length of the latter does not exceed the bore of the tube, are of comparatively large amplitude and length and extend over the whole length of the bubble. As the length increases the wave-length and amplitude and the extent of surface covered by the ripples diminish rapidly, while with a given length of bubble the wave-length diminishes with an increase in the bore of the tube. If the bore is less than about 1 cm. the ripple formation is somewhat peculiar. Immediately ahead of the stern of the bubble a ripple consisting of a single depression of comparatively large amplitude and length is formed, and for lengths greater than about two diameters even this is not fully developed. Where the bubble passes any slight roughness in the interior surface of the tube, however, a series of true ripples of very much smaller pitch make their appearance. The author examined these phenomena for the case of air-bubbles moving through water, using a series of glass tubes of diams. ranging from 0·42 cm. to 7·78 cm. Each tube was mounted vertically, an air-bubble being introduced by means of a rubber bulb at its lower end, and, when the motion had become steady, the time taken to traverse a known distance was measured by chronograph. Instantaneous photographs having an exposure 1/1000 second was taken of bubbles of various lengths up to 8 cm., and specimens of these are given in the paper. In the case of long bubbles, the unexpected result was found that if the bubble is so long as to adopt a cylindrical form, *i.e.* for lengths greater than the bore of the tube, the mean velocity is sensibly independent of the length within the limits of length investigated. Tables of results are given.

Ripple-formation on the surface of a bubble is then experimentally and mathematically investigated. The system of ripples on the surface of a long bubble appears to be analogous to that found at the up-stream side of an obstacle piercing the surface of a running stream, the disturbance produced by the sudden change of section and of velocity in the rear of the bubble being analogous to that due to the presence of the obstacle in the latter case. A series of experiments was carried out to investigate the effect of viscosity and of the solid boundaries. In these a steady stream of water from a vertical nozzle was allowed to impinge on the centre of a circular horizontal glass plate 20 cm. in diam., flow taking place radially outwards in all directions. The discharge was caught and weighed, the depth of the sheet of water being measured at a series of radii by means of a spherometer with a needle-point which was gradually lowered to make contact with the fluid surface. Ripples were then formed at these same radii by means of a needle-point, and their length measured by microscope. The limiting length for stability of flow past the bubbles is finally dealt with, and the result obtained that in very long bubbles stream-line motion breaks down, as indicated by the observed frosted appearance of the film at some distance from the head of the bubble. From data obtained it appears that the larger the tube the thicker the film between bubble and tube for bubbles having similar ratios of length to diam., so that the tendency to instability must be greater in a large than in a small tube. H. H. Ho.

602. *The Surface Tension, Platinum-Water.* **K. Tangl.** (Ann. d. Physik, 42. 6. pp. 1221–1240, Dec. 23, 1913.)—Using the method described previously [Abstract No. 584 (1911)] the author has determined the surface tension, referred to dry and moist air, between caoutchouc-water, collodion-water, shellac-water, and Pt-water. In order to measure the deformations, according to the author's method, a caoutchouc tube was coated with either shellac or collodion, and, for the measurements with Pt, afterwards coated with Pt by kathodic disintegration. The surface tension referred to dry air varies considerably for the different substances, but is approximately the same when referred to moist air, probably because of an adsorbed layer of moisture. The surface tension Pt-water is constant when the thickness of the Pt layer is greater than 52 $\mu\mu$. T. S. P.

603. *The Energy Systems accompanying the Motion of Bodies through Air and Water.* **J. B. Henderson.** (Inst. of Naval Architects, Trans. 55, Part I, pp. 83–93, 1913. Engineering, 95. pp. 549–550, April 18, 1913.)

604. *Methods of Physical Science and their Range of Applicability.* **A. G. Webster.** (Science, 39. pp. 42–51, Jan. 9, 1914.)—A semi-popular survey of the methods, progress, and range of physical science. E. H. B.

605. *Correlations of Pressure and Temperature in the Northern Hemisphere in Winter.* **F. M. Exner.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1165–1240, June, 1913.)—This is an account of a systematic investigation by the method of correlation coefficients into the inter-relations of deviations from normal of monthly means of temperature and pressure in the winter months over the Northern Hemisphere. Forty-nine stations distributed as evenly as possible are selected, and the means of pressure and temperature for the months Dec., Jan., and Feb., for each of the 20 years 1887 to 1906, are extracted. A correlation coefficient of $-0{\cdot}57$ is found between the mean of the pressures at the polar stations Markowo and Gjesvaer and the west component of wind velocity at Potsdam Observatory, and upon the basis of this result the "polar pressure" is taken to be a measure of the intensity of the general atmospheric circulation, a high polar pressure corresponding with a weak circulation, and *vice versa.* Correlation coefficients are therefore found between polar pressure and simultaneous pressures for all the other stations, and lines of iso-correlation are drawn upon a map of the Northern Hemisphere to show the results. Naturally they indicate a closed area of high positive correlation around the pole ($> +0{\cdot}8$), and the lines for 0·6, 0·4, 0·2 and 0·0 are closed curves running roughly east and west, situated at increasing distances from the pole. The line of zero correlation lies on the average at about 50° N., and passes through the middle of the British Isles. South of this line as far as the equator the correlation coefficients are everywhere negative, and over the Mediterranean they attain the large value of $-0{\cdot}6$ ($-0{\cdot}70$ at Algiers) where there is a closed curve of that value. Over the West Indies the values are also numerically high (Port au Prince $-0{\cdot}46$). The "see-saw" variations of pressure between polar regions and the lower part of the North Atlantic, which have often been pointed out, are thus strikingly shown, while the method of indicating the iso-correlation lines reveals the markedly zonal distribution of the coefficients in the Northern Hemisphere during the winter months, and proves that an increase of pressure at the pole is compensated by a decrease in low latitudes, and conversely.

Correlation coefficients are similarly obtained between polar pressure and simultaneous monthly means of temperature at all the stations, and lines of iso-correlation for these are also shown on a map. The main features of this map are (1) high negative values over Northern Europe and Asia, with minimum (< — 0·6) over the British Isles; (2) positive correlation (> + 0·4) over the South-Eastern Mediterranean; (3) positive values (> + 0·4) over Davis Strait, and (4) negative values (< — 0·2) over the West Indies. The lines of zero correlation run (*a*) north and south up the middle of the Atlantic, over the pole and out over the Pacific; (*b*) east and west across the United States; (*c*) east and west along the north shore of the Mediterranean and out on the Pacific across China. The author shows how this distribution might be predicted in outline from the corresponding map of pressure correlations. To illustrate the meaning of the map it may be stated that high pressure in polar regions in winter is shown to be connected with low temperature over the British Isles (see (1) above) in winter. Correlations of pressure between pairs of stations are worked out, and the results plotted on a diagram in which the difference in longitude between the stations is taken as abscissa. The partial correlations of the same pairs of stations are also given, assuming polar pressure to be constant, *i.e.* eliminating the effect of variations in the intensity of the general circulation. In the former case the curve obtained shows large sinuosities, in the latter it is much more regular. The general result from both diagrams is that the algebraic value of the correlation coefficient gradually decreases from + 1·0 at 0° difference of longitude to — 0·4 at 180° difference.

In the second part of the paper an examination by means of the methods of partial correlation is made into the connection between conditions at one station in one month and the ascertained conditions at other stations *in the preceding* month, and equations are obtained which might form the basis of a forecast of weather for a month in advance. Thus an equation is derived connecting pressure at Stykkisholm (Iceland) with the preceding month's pressures at Lemberg, Ivigtut and Jakutsk, while a second equation gives a value for pressure at Ponta Delgada (Azores) in terms of the preceding month's temperatures at Novorossisk, Gjesvaer and Jakutsk. R. C.

606. *Studies of the Nocturnal Radiation to Space.* **A. Ångström.** (Astrophys. Journ. 39. pp. 95–104, Jan., 1914.)—The paper describes some experiments made to determine the amount of the nocturnal radiation from the surface of the earth to different parts of the sky. The apparatus used consisted of an Ångström nocturnal compensation instrument shielded behind a hemispherical screen with a small circular opening in the line perpendicular to the radiating strips. The whole apparatus could be turned about so that the opening faced different parts of the sky and thus measurements were made of the "effective radiation"—that is, the difference between the outgoing and the incoming radiation—from a surface lying perpendicular to the radiated beam. From this the radiation from a horizontal surface like that of the earth to different zones of the sky can be computed. Observations were made at Bassour, Algeria, and curves are given in the paper for three occasions of different surface humidity. Measurements in the daytime have to take account also of the diffuse radiation from the sky of short wave-length which comes in addition to the pure temperature radiation. From such measurements the author concludes that this diffuse sky radiation overpowers the "effective temperature radiation to the sky" or resultant night radiation, to a slight degree. The result differs from that of Homén who concluded that there was an effective radiation from the earth to the sky even in the daytime. J. S. Di.

607. *Air-waves in Valleys according to Records from Variographs in Innsbruck.* **W. Schmidt.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 885–911, May, 1913.)—Two "variographs," or instruments which record the rate of change of atmospheric pressure [see Abstract No. 569 (1913)], were set up in Innsbruck for these experiments. Many hours before the beginning of föhn the instruments exhibit extremely regular waves with periods varying between 5 and 12 mins. The amplitudes of the waves increase continuously as the warm föhn current aloft sinks to the surface until they suddenly end when the föhn breaks through. The phenomena are explained as air-waves formed in the atmosphere at the upper surface of the cold valley wind over which blows the warm current of the föhn. The variations in pressure immediately below the interface between the two air-currents, occasioned by the troughs and depressions of the waves, are transmitted without change to the surface where they are recorded on the variographs. The observed results agree well with those obtained by the theory of waves formed at the interface between two fluids moving with different velocities. The max. height of the air-waves, from crest to trough, is shown by the application of the theory to be of the order of 100 to 150 metres, corresponding with a pressure-variation of at least 4 mm. of mercury. The length of the waves is of the order of kilometres and their velocity is about half that of the föhn. The presence of air-waves as indicated by the variograph is regarded as evidence of rapid variations in the density and velocity of the air-layers aloft, while absence of air-waves shows that the atmosphere aloft exhibits regular and normal changes in these quantities. The appearance of air-waves is frequently associated with an advancing depression, and may thus be regarded as a weather prognostic. It is considered that seiches in lakes and föhn-sickness may be connected with air-waves, and it is pointed out that although such waves are shown in a well-developed state in the Alpine valleys, yet they may be produced in any other locality where the required condition of two currents of unequal density, the one flowing over the other, is satisfied. R. C.

608. *Virtual Temperature of the Sky.* **A. Lo Surdo.** (N. Cimento, 5. Ser. 6. pp. 437–451, June, 1913.)—Assumes the visible sky to radiate heat as a black body, and, by noting the temperature of an Ångström radiator, determines the exchange of heat between the two bodies and thus the "virtual temperature" of the sky by Stefan's law. This is done for a station in Naples and another at the observatory on Monte Cimone at an altitude of 2170 m. Measurements taken in August show a rapid fall at Naples at sunset down to about −70° C., and on Monte Cimone down to −23°, setting in rather late and recovering more rapidly at sunrise. E. E. F.

609. *Sunshine Record at Spitzbergen.* **M. Robitzsch.** (Meteorolog. Zeitschr. 30. pp. 594–599, Dec., 1913.)—A description is given of the type of instrument to be used in recording sunshine duration and intensity, comprising a photographic paper cylinder machine, and the method of determining the form of the curves traced by the sun at different altitudes. C. P. B.

610. *Energy Spectrum of the Sun.* **A. Defant.** (Akad. Wiss. Wien, Ber. 122. 2a. pp. 1135–1163, June, 1913.)—A series of comparisons are made of the transmission coefficients by Vogel and Scheiner, and Abbot, and the theoretical values calculated from terrestrial experiments on bodies at high temperatures. C. P. B.

611. *The Hintereis Glacier.* **R. M. Deeley** and **P. H. Parr.** (Phil. Mag. 27. pp. 153–176, Jan., 1914.)—The authors have shown in a previous communication that the ellipse is a very unsuitable form of curve to use for studying the flow of such a glacier as the Hintereis, since it makes the edges of the ice-stream vertical instead of inclined [see Abstract No. 1590 (1913)]. The present paper is a further consideration of this question, especially as regards the curve of glacier slip and its probable amount; the conditions of shear stress and temperature within the glacier; crevassing and viscosity. The surface motion has been found to be the sum of two movements, one a bodily slip of the whole mass on its bed, and the other a result of the differential motion of the ice of the glacier. These movements have received detailed experimental study, the different apparatus used being fully described, and grounds are given for holding that the motion or slip of clean ice upon a hard but slightly rough surface may take place without abrasion of either the rock or ice. The conditions of flow of the Hintereis Glacier itself are then exhaustively considered, curves, diagrams and tables being given, while the paper finally contains a short mathematical discussion of the distribution of shear force in a viscous fluid flowing along Parr's channel. H. H. Ho.

612. *On the General Distribution of Seismic Movements.* **de M. de Ballore.** (Comptes Rendus, 158. pp. 440–441, Feb. 9, 1914.)—The paper is a summary of the principal deductions to be made from Milne's British Association Reports (1899 to 1909), which contains data recorded by 59 observatories. Since hardly a fifth of the earth's surface is accessible to direct observation, Milne's indirect method of attacking the seismological problem has to be adopted. The observational period of eleven years has provided 881 epicentres, and the author draws many interesting conclusions from their distribution. Among others he points out that the ratio of the number of submarine to terrestrial epicentres is 3 to 1, *i.e.* the same as the immersed to the emerged surface, so that there is uniformity in distribution between subterranean and terrestrial movements. In general the degree of seismicity is reflected in the geological vicissitudes of the area, so that a new mode of investigating oceanic geology is opened out. A number of interesting applications of the latter conclude the paper. H. H. Ho.

613. *Impersonal Coincidence Micrometer.* **A. Verschaffel.** (Comptes Rendus, 157. pp. 975–977, Nov. 24, 1913.)—The author criticises the claims of Claude and Driencourt with respect to their new impersonal coincidence micrometer [Abstract No. 177 (1914)], pointing out that it by no means eliminates personal equation; for although several of the usual effects of personal equation may be allowed for, others will be introduced. It is also considered that the instrument will be difficult to construct and laborious to use. C. P. B.

614. *Absence of Refraction in Solar Atmosphere.* **G. Gouy.** (Comptes Rendus, 157. pp. 1111–1114, Dec. 8, 1913.)—In a former note [Abstract No. 1797 (1913)] it was suggested that it was unnecessary to consider the effect of refraction in the solar atmosphere on account of the extreme tenuity of the constituent gases. A few theoretical points are now considered in the application of the results of laboratory experiments to the interpretation of solar phenomena. With respect to the suggested action of anomalous dispersion, it is pointed out that such phenomena generally require the presence of relatively great density gradients, while the evidence available points to the solar atmospheric gases being extremely rare. C. P. B.

615. *Notes upon Hale's Investigations for Determining the Sun's Magnetism.* **K. Birkeland.** (Comptes Rendus, 157. pp. 394–396, Aug. 25, 1913.)—Hale has recently stated [Abstract No. 34 (1914)] that the sun is magnetic with polarity analogous to that of the earth, and having a vertical intensity at the poles of about 50 gauss. To the present author these results seem to contradict those of other researches when the general magnetism of the sun is assumed to conform to that of the earth, since the helio-kathodic rays which produce the terrestrial magnetic perturbations and aurora would never reach the earth if the sun were magnetised similar to the earth but with an intensity 70 times as great [see Abstract No. 781 (1913)]. Hale, however, is of the opinion that solar magnetism differs radically from that of the earth, since it is probable that the field intensity decreases rapidly after traversing the reversing belt. This presents an interesting resemblance to the field produced by sun-spots. To the author it appears that the effects produced may be explained as due to invisible spots or to electric whirls, in spite of all the reasons urged by Hale against such a supposition. The author gives a reasoned argument in the paper in favour of his standpoint and against that taken up by Hale. According to the author's researches the magnetic moment of the sun is of the order 10^{28} c.g.s. and the magnetisation is directed in a contrary sense to that of the earth. H. H. Ho.

616. *Eclipse Spectrum of Chromosphere.* **S. A. Mitchell.** (Astrophys. Journ. 38. pp. 407–495, Dec., 1913.)—The paper gives the detailed results of the measurement of the spectra obtained at Daroca, Spain, during the total solar eclipse of Aug. 30, 1905, a preliminary account of which has already been published [Abstract No. 853 (1906)]. The spectrographic equipment consisted of five instruments, three of small and two of large dispersion. The present paper deals chiefly with the results given by the large instruments: (1) a parabolic grating 4 in. diam. and 5 ft. (150 cm.) focal length, with 14,438 lines to the inch; (2) a plane grating, with 15,000 lines to the inch, used in conjunction with a 5-in. visual lens of 72 in. (184 cm. focus). The spectra obtained at third contact, the end of totality, were selected for measurement, and tables of 2841 lines are given, extending from λ3318·16 to 6191·6, with the probable origin, relative intensities of the lines in Fraunhoferic, chromospheric, arc and spark spectra, and the estimated height of the layer giving each line, determined from the length of the bright arc left uncovered by the eclipsing moon. Out of the whole 2841 lines only 126 are unidentified as regards the elements producing them. The general list of elements present is practically identical with that giving the substances represented in the solar spectrum, but the distribution of the relative intensities of the lines is widely different. This is summarised by dividing the elements present into three groups: (1) elements whose lines are strong in both the Fraunhoferic chromospheric spectrum, Ca, Mg, Al; (2) elements whose lines are relatively stronger in the chromospheric than in the solar spectrum, H, He, Ti, Cr, C, V, Zr, Sc, La, Y, Sr, Ba, Nd; (3) elements whose lines are relatively weaker in the chromospheric than in the solar spectrum, Fe, Ni, Co, Mn, Na, Nb, Mo, Pd. No conclusive evidence was obtained of the presence of radium or the other radio-active elements. C. P. B.

617. *Change in Lunar Crater Eimmart.* **W. H. Pickering.** (Astronom. Nachr. No. 4704. Nature, 92. p. 594, Jan. 22, 1914. Abstract.)—Observations at the Harvard Station at Mandeville, in Jamaica, indicate that some change has recently taken place in the lunar crater Eimmart. The crater lies on

the N.W. border of the Mare Crisium, and is about 25 miles in diam. Formerly this crater appeared at each lunation much brighter than any similar area between it and the limb, as if it were filled with white material, the source of which appeared to be at the foot of the northern interior slope. During the last year the whiteness appears to have decreased, and recently the phenomenon has not been visible. C. P. B.

618. *Ultra-violet Solar Spectrum at High Altitude.* **A. Wigand.** (Deutsch. Phys. Gesell., Verh. 15. 21. pp. 1090–1099, Nov. 15, 1913. Phys. Zeitschr. 14. pp. 1144–1148; Discussion, p. 1148, Nov. 15, 1913. Paper read before the 85. Naturforscherversammlung. Wien, Sept., 1913.)—Numerous measurements of the ultra-violet solar spectrum have been made by various workers to determine the extreme wave-lengths transmitted by the earth's atmosphere at different altitudes. Of the ordinary observations quoted the highest was at Montersa, at an altitude of 4560 m., where the extreme wave-length recorded was near $\lambda 2912{\cdot}1$. Recent observations by means of a specially constructed quartz and calcspar spectrograph attached to a balloon have provided records up to 9000 m., the extreme wave-length being 2896·10. The extension is thus not very much more than at moderate elevations, indicating that the bulk of the absorption takes place in the lower, denser strata. C. P. B.

619. *Planetary Motions.* **M. Behacker.** (Phys. Zeitschr. 14. pp. 989–992, Oct. 15, 1913.)—Shows that Nordström's gravitational theory [Abstract No. 854 (1913)], based upon the relativity principle, represents fall in a vacuum and the motion of a planet in the gravitational field of the sun in accordance with observation and with Kepler's laws. E. E. F.

620. *Extension of Faye's Theory of Planetary Systems.* **E. Belot.** (Comptes Rendus, 157. pp. 1374–1376, Dec. 22, 1913.)—Taking Faye's supposition that the primitive sun comprised a spherical nebulosity in which the density of successive layers varied with the radius, an analysis is given for finding the position of layers of special properties, for instance, the layer containing most matter, and the layer having max. centrifugal force. In this layer there would be a separation of the lighter and heavier constituents, and reducing the values found it appears that the radius corresponding to greatest centrifugal force would be about that of the orbit of Saturn, which would accordingly have the minimum density; it is also shown that such a system would have its maximum mass at the distance corresponding to Jupiter. C. P. B.

621. *Constants of the Solar System.* **F. Ollive.** (Comptes Rendus, 157. pp. 1501–1502, Dec. 29, 1913.)—A table is given showing the close agreement of observation and calculation in the application of a formula connecting the mean distance of a satellite, its velocity round its primary, the mean distance of the planet from the sun, and the radius of the planet. Except in the cases of Uranus and Neptune the agreement is very good. C. P. B.

622. *Bright Hydrogen Lines in Stellar Spectra.* **P. W. Merril.** (Lick Observatory Bull., No. 246.)—A description is given of a series of stellar spectrograms showing bright hydrogen lines in the H_a region, taken with the 36-in. refractor and a single-prism spectrograph. Details are also given of a special spectrum of P Cygni obtained with a 3-prism spectrograph. C. P. B.

623. *Spectroscopic Observations of Nova Geminorum at Pulkowa with the aid of Bredikhin's Astrograph.* **H. B. Vojtkevič-Poliakova.** (Acad. Sci. St. Pétersbourg, Bull. 8. pp. 191–218, 1914. In Russian.)—The star Nova Geminorum No. 2 was observed at Pulkowa spectrographically in 1912 and 1913. Photographs of the spectrum were obtained by the Bredikhin astrograph, using an objective prism. A very large number of spectrograms were taken in the spring of 1912, when remarkable and abrupt changes occurred in the spectrum of the new star. All the spectrograms were obtained with an objective prism of 20° refractive angle, and a length of spectrum on the photographic plate between spectral lines H_β and H_ϵ equal to 6·3 mm. In 1913, when the star had become notably weaker, another prism was used for the photographs having a refractive angle of 12°. The length of the spectrum in this case was equal to 1·8 mm., between the same lines. The focal length of the camera was 800 mm. The spectrograms were taken by H. A. Tikhoff except for two which the author obtained in unfavourable weather. In them the spectrum was remarkably faint, but certain very intensely bright lines are distinguishable. The observations commenced on March 15, 1912, about two days after the discovery of the star, the delay being occasioned by bad weather prior to that date. Characteristic hydrogen bands were present. From the autumn observations of 1913 it is judged by the author that the nebular spectrum will prevail at the present time (1913, Nov. 27). Tables are given of wave-lengths of lines measured. From the plate of March 15, 1912, it is asserted that helium lines, λ4922 and 5016, were perceptible, but not λ4471. It is possible that the faint absorption bands λ4307, 4459, and 4579 correspond with spectral lines of calcium λ4308, 4455, and 4582. The author thinks that band λ4635 is sufficiently approximate to suggest a relationship to the known band λ4640 relating to Campbell's nebula spectrum and observed in the spectra of Nova Persei (λ4639), Nova Geminorum No. 1 (λ4643), and Nova Lacertæ (λ4644). Many faintly bright lines between H_β and K of the Pulkowa spectrogram of March 15 have been observed in the spectra of Nova Aurigæ and Nova Persei and indicate the presence of Fe, Ti, Cr, Se, and Sr. On March 17, 18, and 26, 1912, helium is again evident. In April, as in the previous month, the author noted a bright band λ5170 ascribed possibly to magnesium. The tables cannot profitably be abbreviated. Some of the photographs are given with the article, but it is not possible conveniently to reproduce them in this Abstract. Two of these relate to March 15, 1912, the second plate being sensitive to red rays. The author remarks that on this day the continuous spectrum was very bright. On the first plate the ultra-violet end of the spectrum could be traced to λ3700. In the region of long waves the continuous spectrum extends to H_α, as is evident on the second plate. In the region from H_β to H_α the spectrum is feeble. Many absorption bands and lines are particularly perceptible on the spectrogram of March 15. Exceedingly fine absorption lines are grouped in various parts of the spectrum which are well noted in the second plate. Very intense absorption bands are presented by $H + H_\epsilon$ and K, and after these follow H_δ, H_β, H_γ, H_ζ, H_η, H_ϑ, H_ι, H_χ. The last five bands are seen only on the second plate.

On March 16, 1912, the ultra-violet end of the spectrum was very strong and extended to λ3600. The continuous spectrum was notably fainter than on the 15th. Narrow absorption lines had now widened, and, in many cases, coalesced and formed wide absorption bands, especially in the region between H_γ and H_δ, characterised on the 15th by groups of fine lines. By the 3rd and 4th of April the continuous spectrum was bright in the region H_β—H_ϵ, but otherwise feeble. The ultra-violet end had rapidly weakened and the absorption bands in the region H_ϵ—H_δ had disappeared. On Feb. 11 and 13, 1913 (photograph is given for the latter day), considerable change was noticeable. The continuous spectrum gave only feeble traces between H_γ and H_ϵ. It was sensitive also in the ultra-violet region. Separate bright bands stand out with exceptional sharpness. The relative brightness of the bands was greater than those of 1912. The prevalent hydrogen bands were now not remarkable. In Oct., 1913, weak traces of the spectrum were observed, consisting of separate bright bands. It was possible to make out bands λ5010, 4640, 4313, and H_δ. A continuous spectrum could be perceived extending to λ3790 in the ultra-violet region. The last spectrogram was taken on Oct. 13, 1913. E. O. W.

624. *Europium Lines in Stellar Spectra.* **F. E. Baxendall.** (Roy. Astronom. Soc., M.N. 74. pp. 32–37, Nov., 1913.)—In a former note [Abstract No. 52 (1914)] it has been pointed out that special lines in the spectrum of *α* Canum Venaticorum obtained by Bélopolsky at Pulkowa agreed closely in wave-length with the strongest lines in the spectrum of europium. The presence of europium in celestial spectra has already been recognised by Dyson and Lunt. A search has now been made for such lines in the various photographs of stellar spectra available. The evidence is considered to confirm the presence of europium in stars of Harvard type A (pec) and A_0; in stars of type A_2 (pec) and F_5 it is weak and inconclusive, and in stars of type earlier than A_0 there is no evidence of its presence. C. P. B.

625. *Photographic Magnitudes of North Polar Stars.* **S. Chapman** and **P. J. Melotte.** (Roy. Astronom. Soc., M.N. 74. pp. 40–49, Nov., 1913.)—Determinations of photographic magnitudes of a number of faint stars in certain special regions were made for standardisation of the star-counts being made on the Franklin-Adams chart plates. Photographs of the star-field and the polar stars are made in the order pole, field, field, pole, each of 6 minutes' duration, giving stars down to the 13·5 magnitude with the 26-in. Greenwich refractor. Another series of plates is then taken with a diffraction grating over the object-glass, producing a series of diffracted images of each star differing by a prearranged definite magnitude-interval. The magnitudes of 262 stars within 25 minutes of arc from the pole are given in the present paper, with a drawing showing their relative positions for reference.
C. P. B.

626. *Photographic Stellar Photometry by Diffraction Gratings.* **S. Chapman** and **P. J. Melotte.** (Roy. Astronom. Soc., M.N. 74. pp. 50–58, Nov., 1913.)—For some years past various investigators have employed coarse diffraction gratings placed over the telescope objectives for the determination of magnitude *intervals.* Auxiliary images are produced on either side of the ordinary central image, diverting a certain constant proportion of light into each image depending on the constant of the grating. An important advantage of the method is that the auxiliary comparison images are produced at the same time as the central ones, and are therefore independent of the constancy of atmospheric transparency, etc. Examples are given of the method of using the apparatus, and tables showing the accuracy attainable. C. P. B.

627. *Radial-velocity Determinations with Prismatic Camera.* **M. Hamy.** (Comptes Rendus, 157. pp. 81–88, Jan. 12, 1914.)—In a former paper [Abstract

No. 208 (1914)] a method was proposed for employing a special form of objective grating camera for the determination of stellar radial velocities. A discussion is now given of an attempt to adopt the objective-prism form of stellar spectrograph to the same problem. The base of the prism is polished and silvered, and the prism so adjusted that while the light from a star transmitted through the glass is brought to focus as a spectrum band, the light reflected from the base is brought to focus as a simple star-image in the focal plane. Special means are described for obtaining the proper alignment of the instrument, and for photographing a comparison spectrum alongside the stellar spectrum for wave-length and velocity determinations. C. P. B.

628. *Variable Radial Velocity of* 118*a Piscium.* **O. J. Lee.** (Astrophys. Journ. 38. pp. 502–504, Dec., 1913.)—The variable velocity of this double star, having components of magnitudes 5·2 and 4·8, type A_3p, was established immediately after the second and third plates had been secured. To obviate the possibility of any influence due to the spectrum of the fainter star the images of the two were separated on the slit. The spectrum of the brighter star gives velocities from −0·8 to +28·7 km. per sec.; that of the fainter star gives velocities from −1·8 to +22·9 km. per sec. It is hoped that spectrograms with larger dispersion will be subsequently available for the study of this interesting system. C. P. B.

629. *Star Positions and Galactic Co-ordinates.* **R. T. A. Innes.** (Observatory, No. 470, pp. 58–64, Jan., 1914. Paper read before the S. African Assoc. for Advancement of Science, July, 1913.)—Attention is drawn to the great labour and a certain degree of uncertainty involved in the designation of star positions as at present referred to the rapidly changing datum planes in right ascension and declination. It is suggested that, in view of the standards in future being chiefly dependent on measurements of photographs of the sky, an attempt be made to adopt the galactic co-ordinates for standard catalogue positions. C. P. B.

630. *Dynamics of a Globular Stellar System.* **A. S. Eddington.** (Roy. Astronom. Soc., M.N. 74. pp. 5–16, Nov., 1913.)—As an introduction to the study of a hitherto uninvestigated type of dynamical system the paper gives an analysis of the dynamics of a globular stellar system. The stars are supposed to move under the central attraction of the whole system, and to be undisturbed by their immediate neighbours, and a search is made for distributions of velocity which yield a steady state for the whole system. C. P. B.

631. *Dark Regions in the Sky.* **E. E. Barnard.** (Astrophys. Journ. 38. pp. 496–501, Dec., 1913.)—In various regions of the sky, especially in the Milky Way, there are certain isolated regions apparently quite devoid of stars, and showing so dark on photographs as to suggest the presence of masses of absorbing material. Well-marked examples occur in the great nebulosities near the stars ρ Ophiuchi and ν Scorpii. [Abstract No. 802 (1910).] Photographs of two of these objects are reproduced with the paper. C. P. B.

632. *Influence of Atmospheric Dispersion on Stellar Photographs.* **St. Chevalier.** (Comptes Rendus, 157. pp. 1377–1379, Dec. 22, 1913.)—From a discussion of 1883 photographs of the sun's disc it is found that the vertical diameter is augmented by a quantity $=0{\cdot}17'' \tan z$ (z being the zenith distance of the object under observation). These results apply specially to photographs taken with an objective achromatised for G and H. C. P. B.

633. *Statistics of Star Clusters.* **H. Chrétien.** (Comptes Rendus, 157. pp. 1047–1050, Dec. 1, 1913.)—In applying the analysis proposed by Zeipel (*Ann. de l'Obs. de Paris,* 25) to the study of star clusters, several modifications are described which facilitate the practical study of measurements of photographs of such clusters. The results are to be applied to measures of clusters taken at Mount Wilson, California, with the 60-in. mirror. C. P. B.

634. *Changes in Tuttle's Nebula.* **Borrelly.** (Comptes Rendus, 157. pp. 1377–1379, Dec. 22, 1913.)—This remarkable nebula was discovered by Tuttle in 1859, and was specially observed in 1862 by D'Arrest; later also by Argelander, Auwers, and Bigourdan. All of these observers describe it as of about the tenth magnitude. From observations during the period 1889 to 1907 it appeared to diminish sensibly, and the brightness had apparently decreased so much by July, 1913, that it is recorded as being scarcely perceptible, probably not more than 11·5 magnitude. It is thought there is evidence of real changes in the brightness of the nebulosity. C. P. B.

635. *Calculation of Circular Orbit from One Photograph.* **L. Picart.** (Comptes Rendus, 157. pp. 1503–1505, Dec. 29, 1913.)—A method is outlined whereby, by measuring the length of trail of a planet and its direction on a photograph showing standard stars, it is possible to determine the elements of a circular orbit with sufficient accuracy to ensure the recognition of the object. The procedure would be of special utility in the observation of minor planets. C. P. B.

LIGHT.

636. *An Immersion Ultramicroscope.* **R. Zsigmondy.** (Phys. Zeitschr. 14. pp. 975–979, Oct. 15, 1913.)—Describes an improved ultramicroscope of greater illuminating power, obtained by increasing the apertures both of the illuminating and the observing objectives. The objectives preferred have a focal length of 6 mm. and a numerical aperture 1·05. The front lens is of quartz, with an over-hemispherical surface, bearing in front a conically ground piece of quartz. The advantages claimed are a shortening of the path traversed by light in the observed substance, the possibility of working on a single drop of liquid, or the reduction of the vessel to the smallest dimensions. Gold and silver particles may be photographed even without retarding their Brownian motion by means of gelatine. E. E. F.

637. *Spectrograph.* **C. Leiss.** (Phys. Zeitschr. 14. pp. 973–975, Oct. 15, 1913.)—A description of a high-luminosity spectrograph for the visible region, in which a simple lens is used instead of a photographically corrected camera objective. The aperture of the collimating lens is F/4, and that of the camera lens F/6, with a free diam. of 4 cm. The dispersing body is a Rutherford prism. No part of the instrument is made of wood. For the photography of spark spectra, with a spark-length of 8 cm., at a distance of 10 cm. from a slit 0·02 mm. wide, the exposure is about 2 to 3 minutes for mean wave-length. E. E. F.

638. *Leitz's New Binocular Microscope.* **F. Jentzsch.** (Phys. Zeitschr. 15. pp. 56–62, Jan. 1, 1914. Roy. Microsc. Soc., Journ. pp. 1–16, 1914.)—A single objective is used, and the light after passing through this is partly reflected and partly transmitted through a semi-transparent layer of silver on one face of a reflection prism. The resulting two beams are by means of other prisms caused to enter the two eyepiece tubes of the instrument. The prisms are so arranged that the two beams have the same length of path in glass. The arrangement has a certain stereoscopic effect, which is discussed. A. W.

639. *Radiometer for a Monochromator.* **W. W. Coblentz** and **C. Leiss.** (Zeitschr. Instrumentenk. 34. pp. 14–18, Jan., 1914.)—A description is first given of the Bi-Ag thermo-element, 22 to 24 couples being used, and the alternate junctions being arranged in a vertical line, each junction in this line being attached to a small silver plate of dimensions 2 × 0·7 × 0·025 mm.; these plates are coated with platinum- and lamp-black. Diagrams are given of the complete arrangement for use with a Fuess monochromator, the thermo-element being contained in an evacuated chamber. A. W.

640. *Adjustment of Telescope by Auto-collimation.* **G. Lippmann.** (Comptes Rendus, 158. pp. 88–91, Jan. 12, 1914. Journ. de Physique, 4. Ser. 5. pp. 97–100, Feb., 1914.)—A delicate device is described for the exact auto-collimation of telescopes by the reflection method. A very fine slit produced by a diamond scratch on a silvered glass plate is illuminated by the light source, the light then passing on to the objective under test and the

reflecting surface, generally a bath of mercury, from which it is sent back towards the slit. The glass plate bearing the slit is put at 45° to the axis of the objective, and the fine slit viewed with an eyepiece. In most cases it will be found that the reflected image of the slit is visible near the slit itself, but it will be then possible by means of a fine micrometer screw to adjust matters so that the image just returns through the slit, and nothing is visible in the eyepiece. As an example of the accuracy attainable, it was found possible, with an objective of 2 m. focal length, to set the slit in collimation to about 1·5 μ, corresponding to about 0·15″ of arc. C. P. B.

641. *Refractive Indices of Liquid Crystals.* **W. Kreide.** (Phys. Zeitschr. 14. pp. 979–981, Oct. 15, 1913.)—Determines the refractive indices of cholesteryl chloride and nitrobenzoate for the red Li line, the D lines, and green and blue Hg lines. The results are given in curves for various temperatures. In the second substance the liquid-crystalline phase extends from 141° to 77° C. E. E. F.

642. *Media of High Refractive Power for Photomicrography.* **C. Jones.** (Photographic Journ. 54. pp. 14–25; Discussion, pp. 25–26, Jan., 1914.)—A paper dealing in detail with various media of high refractive power. These include styrax, liquidambar, monobromnaphthalene, piperine and mixtures of piperine, and media containing arsenic and sulphur. Styrax requires first hardening by being kept warm for a considerable time, but the ordinary subsequent treatment may be modified by dissolving the hardened styrax in only about its own bulk of benzene and filtering the syrupy solution through ordinary filter-paper, when it is at once ready for use. Liquidambar, stated by Van Heurck to have a rather higher refractive index than styrax, may be treated in exactly the same way. Monobromnaphthalene, a liquid with an index of 1·66, is very convenient for temporary use. Piperine has an index of 1·68, and is easy to use, since it melts at 128° C. to a thin watery liquid. In small thicknesses it is free from colour. Fused piperine begins to go opaque because of crystallisation in about a month, but the process of crystallisation is slow in a microscope slide, slides prepared with piperine showing a considerable area in good condition several months after preparation. If the piperine is first heated for an hour to 180° C. it is found that after the lapse of 2 years crystallisation has not started. Piperine has a high dispersive power in addition to its high refractive index, which latter is given by Madan as 1·710 for the E-line and 1·738 for the F-line. For some purposes the high dispersive power may be advantageous. A slide made in 1891 with a mixture of piperine and antimony bromide is in perfect condition still, but one made in 1889 with a mixture of arsenious bromide and piperine has gone nearly opaque at the extreme edge, though a large portion is still in good condition. A lengthy discussion is given of media containing arsenic and sulphur, various methods of treatment being noted. The chief troubles that attend the use of pure realgar (As_2S_2) are the high temperature necessary, the cracking, and the separation from the glass; to avoid these sulphur is added to it. Research showed that a mixture of 7 parts As with 22½ to 30 parts S was satisfactory. With less sulphur the mountant cracks and comes away from the glass; with more sulphur there is a tendency to crystallise, which is more marked the greater the proportion of sulphur. The methods of purification, and of mounting with these As-S media are described. Arsenious bromide is not recommended. The selenium-sulphur mixtures described by Merwin and Larsen [Abstract No. 1680 (1912)] are also dealt with. A. W.

643. *Double Refraction of Metallic Films obtained by Kathodic Deposition.* **C. Bergholm.** (Ann. d. Physik, 43. 1. pp. 1–23, Dec. 31, 1913.)—A glass plate introduced into a discharge tube and arranged with its plane perpendicular to a leaf-shaped kathode receives, when the discharge takes place, a wedge-shaped metallic film, symmetrical with respect to the kathode, and this film is doubly refracting. The double refraction of such films was investigated for different-coloured light, the metals used for kathode being Ag, Pt, Pd, Bi, Cu, and Au. A theoretical discussion is given. A. W.

644. *Michelson-Morley Experiment.* **J. Rose-Innes.** (Phil. Mag. 27. pp. 150–153, Jan., 1914.)—To explain the negative results of the above experiment Fitzgerald put forward his hypothesis of the contraction along the line of motion. But this contraction has not been directly observed. The failure to confirm this contraction led to the theory of relativity, in which, with a good deal of metaphysical subtlety, all our notions of time and space are revised.

It seems to have been overlooked that a third solution is possible, viz., that, even though there be no dragging effect, such as Lodge searched for, a change in the constants of the ether may perhaps take place, owing to the motion of a large mass in the neighbourhood. Thus at the surface of the earth the ether may be supposed to alter slightly in its properties, owing to the orbital motion. It may be imagined that the velocity of an ethereal disturbance parallel to the motion of the earth is unaltered, but that at right angles to the orbital motion the velocity of a disturbance is $V - u^2/2V$, where V is the velocity of light in free ether, and u is that of the earth in its orbit. Any other simple function of V and u agreeing with the above as far as squares of small quantities would, of course, answer the purpose equally well in the present state of our experimental knowledge.

The correction-term suggested above is applicable to measurements at the surface of the earth; at considerable distances from the earth the effect of its motion ought clearly to be taken as smaller. Allowance for this falling-off in the effect is made by supposing that the correction is more nearly represented by an expression of the form $u^2/2V \,.\, (1 - e^{-G})$, where G is a function of the mass and the distance, akin to gravitation, in so far as it is large in the neighbourhood of massive bodies and becomes small as the masses are smaller or the distances greater.

There is an imaginary experiment worth noting which would give different results according as we adopted the present theory or that of relativity, and which might therefore serve as an *experimentum crucis*, could the experimental difficulties be removed. If one could detach Michelson and Morley, together with their apparatus, from the earth and send them travelling along at the rate of 19 miles per sec. in the free ether, the absence of the earth would make no difference according to the theory of relativity, but would cause a displacement of the fringes according to the present theory. There are, however, very grave difficulties in the way of the actual experiment, and it will be some time before they are overcome. E. H. B.

645. *Diffraction of Light by Particles Comparable with the Wave-length.* **B. A. Keen** and **A. W. Porter.** (Roy. Soc., Proc. Ser. A, 89. pp. 370–376, Jan. 1, 1914.)—This research was undertaken to investigate an effect noticed when experimenting with the light scattered by suspensions of finely-divided sulphur. These were obtained by depositing sulphur from a solution of sodium thiosulphate by means of a weak acid. When such a suspension is

placed in the path of a beam from an arc lamp focused on a screen, the image of the carbon is usually red, of greater or less depth according to the size and number of the diffracting particles. The explanation of this has been given by Rayleigh. But if time be given for the particles to increase in size, and possibly in number also, the solution after becoming nearly opaque becomes transparent again, and in this new stage an excess of blue is transmitted, which attains at one stage a deep indigo tint, this afterwards changing through various blue-green and green tints to white. Analogous phenomena have been observed by Abney and Ritz, and show that the phenomenon is not peculiar to sulphur. The research consisted of measuring, at various instants after setting free the thiosulphuric acid, the transparency of the suspension to monochromatic lights of various wave-lengths. For this purpose a Hüfner spectrophotometer was employed. Light passing first through a fixed nicol, and then through one which can be rotated, is matched with light passing through the solution and the second nicol. On its way the light is sorted into its constituent colours by means of a constant-deviation prism ; the match can therefore be made for any desired colours in succession. Particular care had to be taken with regard to temperature and stirring. Two typical wave-lengths—one in the blue and the other in the red —were selected, and the complete experiment was performed with one wave-length at a time. The gradual change of the transmitted light from red through blue to white is plainly shown by the curves obtained for the two colours. In the first stages of the reaction the intensity of the blue light falls off more rapidly than the red. At the end of about 8 minutes the blue light reaches its minimum and begins to increase, while the red light is still falling to its minimum. The transmitted light—when due allowance is made for the rest of the spectrum—becomes a purple colour. After the curves cross the blue end of the spectrum predominates, and hence we get the blue colour of the transmitted light, which gradually changes to white as the remaining rays increase in intensity. The minimum and final intensities are the same for each wave-length. The transmitted intensity may be represented by a function of t/λ, where t is the time. With regard to the relation between the diam. of the particles and t more difficulty exists, and further mathematical treatment than that given by Rayleigh is needed, for the size of the particles in the present experiments was considerably greater than those treated by Rayleigh. The growth of the particles is very sensitive to temperature-changes. Some results obtained at about 2° C. did not show the drop and subsequent rise in the intensity of the transmitted light that were obtained at higher temperatures. A. W.

646. *Theory of Moving Mirror.* II. **A. Harnack.** (Ann. d. Physik, 43. 2. pp. 295–308, Jan. 23, 1914.)—The second part of a mathematical discussion of this subject in which the results to be expected under various forms of relativity are examined. It is finally concluded that under the conditions here laid down it is impossible for the speed of light to be influenced by the moving mirror. [See Abstract No. 402 (1913).] E. H. B.

647. *Optical Electrons and Ions.* **K. Kilchling.** (Phys. Zeitschr. 15. pp. 88–96, Jan. 15, 1914.)—An analytical and numerical paper of which the following are the chief results :—1. A new calculation of $p.e/m$ in the ultraviolet on the basis of the improved dispersion data is carried out for fluorspar, rock-salt, sylvine, and quartz. 2. The Thomson dispersion theory is extended by the addition of damping forces in the region of anomalous dis-

persion, and this development applied to the calculation of $p.e/m$ for the infra-red. 8. For rock-salt, sylvine, fluor-spar, and quartz, $p.e/m$ is calculated for the dispersion data in infra-red, for water from the absorption curve.
E. H. B.

648. *Intermittent Vision.* **A. Mallock.** (Roy. Soc., Proc. Ser. A. 89. pp. 407–410, Jan. 1, 1914.)—The spokes of the wheels of passing motor-cars often appear momentarily stationary, and sometimes even seem to be turning in the direction opposite to their actual motion. These appearances, lasting only for a small fraction of a second, coincide with the steps of the observer, and are only noticeable when the speed of the vehicle lies between certain limits. The motion must be too quick for the eye to follow the individual spokes, and must not exceed a certain limit, which is slightly different for different individuals. The effect was examined by using a disc of black paper with 12 equally spaced radial white lines on it. This was spun on a top, which lost its speed slowly. It was found that the lines on the spinning disc appeared stationary not only at each step, but that any slight mechanical shock, such as is given by gently tapping the head, was equally efficacious. With the speed so low that only 9 or 10 lines passed a fixed point in a second the appearance was merely that of ordinary flicker, and when 80 or more lines passed in the same time the surface looked uniformly grey; in both cases mechanical shock had no apparent effect. The impressions received at intermediate stages are described and diagrams given. An explanation of the phenomena can be given on the assumption that a slight mechanical shock of any kind produces a periodic but rapidly extinguished paralysis of the perception of light. Such an explanation is suggested. A. W.

649. *Bending of Plane Waves for any Position of the Incident Plane with Respect to the Bending Edge.* **A. Wiegrefe.** (Ann. d. Physik, 42. 6. pp. 1241–1256, Dec. 23, 1913.)—Mathematical.

650. *On the Luminosity Curve of a Colour-blind Observer.* **W. Watson.** (Roy. Soc. Proc, Ser. A. 89. pp. 36–38, Aug. 1, 1913.)

651. *Absorption by Sodium Vapour mixed with Neutral Gases.* **K. Fredenhagen.** (Phys. Zeitschr. 14. pp. 1047–1049, Nov. 1, 1913.)—Experiments made by mixing helium with Na-vapour show a difference of absorption which is, however, not due to any influence of the neutral gas on the aggregation of the Na-atoms, but solely to the difference of density of Na-vapour produced by dilution. E. E. F.

652. *Ultra-violet Absorption of Acetone.* **H. T. Clark** and **A. W. Stewart.** (Phys. Zeitschr. 14. pp. 1049–1050, Nov. 1, 1913.)—Photographic absorption measurements with pure acetone show the presence of an absorption band in the ultra-violet whose less refrangible edge lies at 336·5 $\mu\mu$. The transmission curve does not show a minimum, but it shows at all events a point of inversion at that wave-length. **J. Stark** adds a note drawing attention to the theoretical importance of this new band. E. E. F.

653. *Wave-length Standards.* **L. Janicki.** (Zeitschr. wiss. Phot. 13. pp. 173–185, Jan., 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—Gives particulars of the determination of a number of third order

normal wave-lengths in the arc spectrum of iron between λ4282 and λ4908. The results are tabulated and compared with those of Burns, Goos, and Kayser. [See Abstracts Nos. 866 (1912), and 1481, 1482, 1486 (1913).]

654. *Standard Wave-lengths of Iron Spectrum.* **C. E. St. John** and **L. W. Ware.** (Astrophys. Journ. 39. pp. 5–28, Jan., 1914. Mount Wilson Solar Observatory, Contributions, No. 75.)—A revised list is given of 198 lines in the spectrum of iron between λ4118 and λ5506, determined from photographs taken with the 75-ft. Littrow spectrograph of the Tower telescope at Mount Wilson. Variations in wave-length of certain lines as determined at Pasadena, at the foot of the mountain, and at the top of the hill are ascribed to pressure effects. C. P. B.

655. *Classification of Spectra.* **F. Croze.** (Journ. de Physique, 3. Ser. 5. pp. 882–900, Nov., and pp. 962–970, Dec., 1913.)—Research is here discussed relating to the classification of spectra according to their structure and their magnetic variations. In the spectra of series lines, the Zeeman-effect presents itself as a normal triplet, not only for the series of single lines, but also for the series of doublets and triplets for fields above a certain value. Observations with hydrogen show that, to obtain concordant results, the phenomena must be investigated under conditions where the electric discharge is not modified by the magnetic field. Study of the Zeeman-effect has not yet resulted in the discovery of the laws of distribution in the spectra of non-series lines. In the case of pure triplets, however, special values are found, and for more complicated decompositions certain similarities are noted. Recent researches on band spectra tend towards the conclusion that the emission bands of gases and vapours are all resolvable, and constituted of series of lines which start from one or many heads and whose law of formation is to a first approximation similar to arithmetic series. The study of the action of magnetic fields permits band spectra to be divided into two classes: those which show the Zeeman-effect and those which do not. Among the latter, all those which have been investigated up to the present in intense fields have their lines slightly displaced by the field in a manner which varies from one series to another, but always in the same way for the same series. With regard to the others, which show the Zeeman-effect, identical separations are found for the heads of any particular series. These facts show that the distribution into series has a true physical significance. In the case of complex spectra like the second spectrum of hydrogen, a systematic study of the Zeeman-effect enables the lines belonging to bands to be separated from those belonging to a line spectrum. Possibly further light may be thrown on the subject by using still larger fields than those employed, of the order of 40,000 gauss. A. W.

656. *Positive Band Spectrum of Nitrogen.* **R. T. Birge.** (Astrophys. Journ. 39. pp. 50–88, Jan., 1914.)—This paper is a preliminary discussion of the first Deslandres' group of the positive band spectrum of nitrogen, based mainly on photographs taken in the second order of a 21-ft. concave grating, from λ5000 to λ6800. A complete discussion of previous work, together with research on the long-wave portion, has been given by von der Helm [see Abstract No. 1485 (1910)]. The results of the present discussion are as follows:—The first Deslandres' group consists really of two spectra, one composed of a large number of superimposed series of lines, the other quite irregular. The similarity in the spacing of all series gives the banded

appearance of the spectrum, the length of a band being the distance between two successive lines of each series. The so-called heads of the bands are formed by groups of particularly heavy lines, accompanied by more or less continuous radiation. It is possible to fit a greater number of lines into the simple series of the von der Helm arrangement of bands than into the more complex two-parameter formula indicated by the Cuthbertson arrangement. All physical changes in the spectrum, however, favour the latter arrangement. Simple series of lines, running through one band group of the von der Helm arrangement obey Deslandres' law for at least the first few bands, but later show a large and systematic deviation from it. The first and second progressions of the Cuthbertson arrangement fit approximately into a formula containing both the second and third powers of the parameter, but will *not* fit the simpler second-power formula of Deslandres' law. The successive band groups have certain heads which approximately coincide, and these points of coincidence show regularities which enable the entire set of bands of the first Deslandres' group to be arranged so as to indicate a definite plan for the group. The 39 bands between λ5000 and λ6800 were resolved into about 6400 lines, a portion of which have been measured with an average error of 0·01 Å. or less. A. W.

657. *Second Spectrum of Neon.* **T. R. Merton.** (Roy. Soc., Proc. Ser. A. 89. pp. 447–451, Jan. 1, 1914.)—Neon when subjected to a jar discharge of small intensity is found to exhibit a spectrum in the more refrangible region entirely different from the ordinary spectrum. The lines of the ordinary spectrum in the orange and red appear much weaker, while the new lines developed and measured down to 3218 Å. have a very considerable intensity and can be observed through the glass of the capillary tube. The lines are measured with a grating spectrograph and the measurements are probably accurate to 0·1 Å. In all cases they correspond closely to lines found by Liveing and Dewar [Abstract No. 1794 (1908)] in the spectrum of the gases of the atmosphere which are not condensed at the temperature of liquid hydrogen. On the other hand, only about one-half the number of lines, apart from those which belong to the spectra of hydrogen and helium, observed by Liveing and Dewar have been recorded, and this deficiency is attributed to the weak illumination afforded by the concave grating as compared with the calcite prism spectrograph used by the last-named workers. C. S. G.

658. *Spectra of High-frequency Discharges in Geissler Tubes.* **R. W. Lawson.** (Phil. Mag. 26. pp. 966–981, Dec., 1913.)—The author has undertaken the following investigation owing to the fact that a variety of spectra can be obtained with many elements according to their mode of electrical excitation. It is therefore desirable to examine spectra obtained by different methods, as such a procedure may greatly assist in the determination of the underlying causes for the production of one or other of the spectra of the element concerned. In the case of vacuum tubes the pressure of the gas, its temperature and purity, the current density and voltage employed, are all known to influence the character of the discharge, but in a way not clearly understood. In the present work the source of current was the Poulsen arc. A detailed description of the apparatus used is given. For the photography of the spectra obtained, a Hilger fixed-arm spectrograph was used, while a Kelvin electrostatic voltmeter was employed for the measurement of voltage across the discharge tube. The discharge current was measured by passing

it through a fine Pt-wire, which heated a copper-constantan thermo-couple, and the resulting e.m.f. was registered on a Paul single-pivot galvanometer. An induction coil was kept conveniently near the discharge tubes, so that the discharge as obtained by the Poulsen generator could be compared with either the condensed or the uncondensed induction-coil discharges. The frequencies of discharge were also obtained by means of a portable wavemeter standardised by a Fleming cymometer. Various methods of direct and inductive coupling were employed between the generating and discharge circuits, and two which were found particularly suitable are described. Whilst it was readily possible to obtain feeble discharges similar to those obtainable using an induction coil, the majority of the discharges from the Poulsen generator were of extraordinary brightness. The advantage of this lay in the fact that very short exposures were necessary, and therefore greater average constancy of discharge conditions maintained for those short intervals. Since the form of the bulb discharge was found to vary greatly according to the pressure and current in use, general descriptions of this for the different gases are given. In none of the cases examined was the frequency of the discharge found to have any influence on the spectrum obtained, this being the same at lower and higher frequencies, other conditions being maintained constant; also no matter how the current and voltage were adjusted was it found possible to produce the condensed discharge spectrum by means of the Poulsen generator. That the oscillatory character of the condensed discharge is the determining factor for the production of the elementary line-spectrum of a gas is thus an untenable suggestion, and it seems probable that the production of the line-spectrum of a gas by use of condenser and spark-gap is dependent on the initial value of the current in the discharge tube at each train of oscillations. The observations made on the different gases are fully recorded.

An interesting method is described for obtaining a steady stream of nitrogen, since the usual methods give a spasmodic and somewhat violent evolution of gas. Briefly this consists in passing a stream of pure chlorine through strong ammonia solution whereby nitrogen, hydrochloric acid, and ammonium chloride are liberated. The latter are removed by repeated washing in air-free water, then passing over solid caustic potash, and, after bubbling through concentrated sulphuric acid, the pure nitrogen is collected over mercury. Photographs are given of nitrogen, air, hydrogen, and argon under the varying conditions outlined above, together with detailed description of the different spectra obtained. Variation of current density and voltage in the discharge tube with internal or external electrodes did not produce any change in the relative intensity of the nitrogen bands in the capillary, but considerable differences are recorded with pressure-changes. In the case of air no oxygen lines were discernible, the spectrum being the same as that of pure nitrogen under every circumstance. The negative-glow discharge in Geissler tubes with internal electrodes failed to show any trace of the spectra of oxygen. Hydrogen was prepared by the electrolysis of an air-free solution of baryta in water, and after bubbling through strong sulphuric acid was collected over P_2O_5. At constant frequency, the series spectrum of hydrogen was greatly enhanced relatively to the secondary or many-lined spectrum when larger current values were used: a similar result to that obtained with increased currents in hydrogen when the induction-coil discharge is used. The appearance of the tube, particularly with the Poulsen discharge, is very striking. At low currents the tube has somewhat of a bluish-lavender colour, whilst at high currents it glows very strongly with a strong ruddy glow.

With gradually increasing current-values the secondary spectrum appeared to increase uniformly, but the primary spectrum showed marked selectivity, the α, β, and γ lines increasing in descending order of magnitude respectively. At higher pressures the external electrode bulbs were rich in the secondary spectrum, but showed the primary spectrum very feebly. Oxygen was prepared by heating potassium permanganate in a glass tube sealed on to the apparatus, a previous heating in an oven at 110° C. for 48 hours being found to remove all moisture. Under all the conditions of voltage, current, and gas-pressure available, the compound line-spectrum was alone obtainable at ordinary temperatures.

Argon, possessing three different spectra, is a particularly suitable gas to test under the conditions of these experiments. The red spectrum is that usually produced by use of the uncondensed induction-coil discharge, the blue by the condensed discharge, while the white is the result of mixed conditions. The author discusses previous work on these spectra. Using the Poulsen generator it appears likely that the initial value of the discharge in each train rather than the mean value of the current determines the spectrum produced; and since the complete transformation from the red to the blue spectrum was obtained by use of a constant-frequency undamped discharge with increasing current values, the author concludes that current density is the main determining influence. With neon, He, and CO the spectra were identical with those obtained when using the induction-coil discharge without condenser. H. H. Ho.

659. *Zeeman-effect in Series Spectra of Oxygen and Hydrogen.* **F. Croze.** (Comptes Rendus, 157. pp. 1061–1063, Dec. 1, 1913.)—Paschen and Back have studied the Zeeman-effect for the triplet 3947 ($\Delta\lambda = 0{\cdot}293$; $\Delta n = 1{\cdot}88$ cm./sec.) of the principal series of oxygen, and for the lines H_α and H_β of the first subordinate series of hydrogen, which they consider as doublets ($H_\alpha \Delta n = 0{\cdot}32$) [see Abstracts Nos. 419 and 1282 (1913)]. Their results are in disagreement, both qualitative and quantitative, with the results of Croze [Abstracts Nos. 1367 (1912) and 420 (1913)], who always found, in fields up to 24,000 gauss, for each of the lines H_α, H_β, H_γ, H_δ, a pure triplet of normal polarisation and normal separation. In Paschen and Back's experiments, however, the discharge tube was arranged perpendicular to the axis of the electromagnet; while in those of Croze the tube was arranged parallel to the axis of the magnet. Croze has now repeated his experiments and also those of Paschen and Back. The results for the oxygen triplet 3947 show that it exhibits the same behaviour whether the tube is parallel or perpendicular to the axis of the electromagnet: the results are in perfect agreement with Paschen and Back's observations. Agreement was also obtained for the hydrogen lines when the tube is perpendicular to the axis of the magnet, but in the case where the tube is parallel to the axis of the electromagnet, with fields ranging from 9000 to 21,000 gauss, the line H_α was always found to give a triplet with normal polarisation and separation. It should be noticed that when the discharge tube is arranged perpendicular to the direction of the magnetic field, the discharge is much altered in character. The cause of this alteration is being investigated.

A. W.

660. *Ultra-violet Bands of One-, Two-, and Three-atomed Oxygen Molecules.* **J. Stark.** (Ann. d. Physik, 43. 2. pp. 319–336, Jan. 23, 1914.)—The research here described shows that the O_3-molecule gives rise to the emission of numerous bands extending from the green to about λ2100, the bands shading

off towards the long wave-lengths and being resolvable into lines. The O_2-molecule gives rise to short-waved bands, resolvable into lines, in the region λ2000 to about λ1850, which correspond exactly with the ultra-violet fluorescence band of oxygen. The so-called ultra-violet water-vapour band extending from λ3400 to λ2800 is found to belong to the O-molecule. It is found to be emitted strongly in pure oxygen in the positive column, and in such compounds containing oxygen as may at low temperatures give rise by dissociation to single O-atoms. A. W.

661. *Electromagnetic Theory in Relation to the Magnetic Effect on the Canal-ray Spectrum of Hydrogen.* **W. Wien.** (Preuss. Akad. Wiss. Berlin, Ber. 4. pp. 70–74, 1914.)—The development of the quanta theory has called into question the validity of Maxwell's theory and its fundamental equations. Of these the equation of the force acting on an electric charge, $f = E + 1/c(vH)$ has been verified for simple cases by the Zeeman phenomenon, but Einstein's deductions from the relativity principle have questioned its general accuracy [Abstract No. 2277 (1905)]. The recent work of Stark has demonstrated the resolution of spectral lines by an electric field (E), and if the equation be written $f = 1/c(E_m + vH)$ it follows that by choosing a suitable magnetic field and using the rays of hydrogen, vH can be made equal to E and an effect similar to that obtained by Stark should result.

The observed broadenings of H_β and H_γ for a suitable arrangement are measured, and they agree in order of magnitude with the calculated amounts, but in most cases are slightly too large. More accurate experiments are contemplated. The field used is about 17,000 gauss, and the discharge voltage varies from 5000 to 14,500 volts, while the velocity, v, is measured by the Doppler-effect. C. S. G.

662. *Variations of Band Spectra in Magnetic Field.* **H. Deslandres** and **V. Burson.** (Comptes Rendus, 157. pp. 1105–1111, Dec. 8, 1913.)—Examination of the spectrum of the blue-cone of an oxycoal-gas flame in magnetic fields of 9500, 17,000, 24,000 gauss resulted in the detection of a complicated series of phenomena requiring further investigation. Separation into polarised components as in the ordinary Zeeman-effect was observed; in addition special displacements, and simplifications of the doublets similar to those described by Paschen, Back, and Fortrat. *Errata* (Ibid. p. 1492, Dec. 22, 1913.) C. P. B.

663. *Inverse Zeeman-effect.* **H. M. Hansen.** (Ann. d. Physik, 43. 2. pp. 169–248, Jan. 23, 1914. Extract from Habilitationsarbeit, Copenhagen.)—Describes an elaborate investigation of the phenomena associated with the inverse Zeeman-effect of the D-lines and the red Li-line. The grating spectrograph previously described [Abstract No. 881 (1912)] was employed. The phenomena dealt with are the longitudinal circular, and the transversal linear double refraction within a magnetically dispersed absorption line. The dependence of the phenomena on the field strength and on the density of the vapour in the flame used, was investigated, the conditions being varied as much as possible. The results are discussed with relation to the theory of dispersion. A. W.

664. *Maximum Separation in Zeeman-effect.* **K. Schwarzschild.** (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 24–40, Jan. 15, 1914.)—A mathematical treatment based on the theory of Lorentz. A. W.

665. *Effect of Electric Field on Spectrum Lines.* **K. Schwarzschild.** (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 20–24, Jan. 15, 1914.)—Warburg has shown [see Abstract No. 460 (1914)] that an explanation can be given, based on Bohr's model atom, of the effect of a strong electric field on the spectrum lines of canal rays. The explanation gives results in approximate quantitative agreement with the experimental values obtained by Stark. In the present paper an electron revolving about a centre is considered, and an explanation of the Stark-effect is deduced, following the ordinary laws of mechanics. The numerical results for the separation are, at any rate for the visible spectrum, of the same order of magnitude as those of Warburg. A. W.

666. *Electric Analogue of the Zeeman-effect.* **A. Lo Surdo.** (Accad. Lincei, Atti, 22. pp. 664–666, Dec. 21, 1913; 23. pp. 82–84, Jan. 18, 1914. Phys. Zeitschr. 15. p. 122, Feb. 1, 1914.)—In attempting to study the Doppler-effect due to retrograde positive rays near the kathode by means of a tube placed obliquely or perpendicularly to the collimator of the spectroscope, the author observed that the hydrogen lines appeared to be decomposed into several elements. This phenomenon is identical with that subsequently observed by Stark [see Abstract No. 238 (1914)]. The line H_γ is decomposed into five polarised elements, the plane of vibration with the two outer ones being parallel, and with the three inner ones perpendicular, to the direction of the field. By means of a special arrangement, the light was observed along a line parallel to the electric field, and, as was to be expected, the H_γ line then shows three elements; for the exposures used by the author, which give but light impressions of the H_γ lines, the spectrogram of these lines is not subject to disturbance by the Doppler-effect of the direct and retrograde positive rays. **A. Garbasso.** (Phys. Zeitschr. 15. p. 123, Feb. 1, 1914.) T. H. P.

667. *Effect of Electric Field on Spectrum Lines.* **A. Garbasso.** (Accad. Lincei, Atti, 22. pp. 635–639, Dec. 21, 1913.)—Stark has shown [see Abstract No. 238 (1914)] that the single ray emitted by an ionised gas is resolved into three or five components by the application of an intense electric field. Observations have also been made by Lo Surdo [see preceding Abstract]. The phenomenon is of great interest theoretically, since it throws new light on atomic structure. The Thomson model atom, at any rate in its original form, does not yield an explanation of the Stark-Lo Surdo effect, and from considerations here advanced it does not appear likely that the modification suggested by Voigt will improve matters in this respect. Bohr's theory applied to Rutherford's model atom, may, however, be modified to explain the effect. Calculations based on this theory give for the distance apart of the outer components of the hydrogen line H_β in a field of 13,000 volts per cm. the value of 8·1 Å. The value found experimentally by Stark was 8·6. A. W.

668. *Structure of Band Spectra.* **R. Fortrat.** (Comptes Rendus, 157. pp. 991–994, Nov. 24, 1913.)—Details are given of the effect of the magnetic field on the band spectra of carbon, cyanogen, and air. [See Abstracts Nos. 1439 (1913) and 468 (1914).] C. P. B.

669. *Series Absorption Lines.* **C. Füchtbauer** and **W. Hofmann.** (Ann. d. Physik, 43. 1. pp. 96–134, Dec. 31, 1913.)—A more detailed account of work previously published [Abstracts Nos. 229, 230 (1914)]. J. M.

670. *X-ray Interference Patterns.* **M. de Broglie.** (Phys. Zeitschr. 14. pp. 994–995, Oct. 15, 1913.)—Adduces arguments against the view that the striation of the patches observed in X-ray interference patterns is due to selective reflection. The striæ of the same patches have very similar absorptions. In the symmetrical transmission diagrams the striæ are not symmetrical to the central ray, but parallel: 123 1′2′3′, and not 321 1′2′3′.

E. E. F.

671. *Diffraction of X-rays and Crystalline Symmetry.* **G. Friedel.** (Comptes Rendus, 157. pp. 1533–1536, Dec. 29, 1913.)—Explains why Laue could find no evidence of the anti-hemihedry of zinc blende, nor any difference in right-handed and left-handed quartz. The only symmetries which radiograms could reveal are holohedry and para-hemihedry. The author gives a table showing the possible symmetries shown by radiograms in each of the 32 forms of crystalline symmetry. Thus, in the cubic system, cubic holohedry may be revealed by crystals having either holohedry, holoaxial hemihedry, or anti-hemihedry; and cubic para-hemihedry may be shown by crystals having para-hemihedry or tetartohedry. E. E. F.

672. *Influence of the Constituents of the Crystal on the Form of the Spectrum in the X-ray Spectrometer.* **W. H. Bragg.** (Roy. Soc., Proc. Ser. A. 89. pp. 430–438, Jan. 1, 1914.)—The author first describes the form of the spectra emitted by different antikathodes [see Abstracts Nos. 1330 (1913) and 86 (1914)]. The spectra of Os, Ir, and Pt show common characteristics: each metal emits three groups of characteristic rays upon which is superposed a general radiation. Palladium and Rh give remarkably simple and similar spectra. The lines from rock-salt (100) occur at angles 10·4° and 11·8° for Pd; 11·0° and 12·6° for Rh. The wave-length of the more intense line in the Pd spectrum is $0{\cdot}576 \times 10^{-8}$ cm., and in the Rh spectrum $0{\cdot}608 \times 10^{-8}$ cm. Nickel and Cu show two noticeable lines in each spectrum. The wave-length increases as the atomic weight diminishes, but the frequency is not found to be quite proportional to the square of the atomic weight. Relative intensities of various parts of the spectrum may be greatly altered by changing the crystal which is used in the spectrometer. It is shown that this may be ascribed to well-known discontinuities in relations between the atomic weight of an absorbing screen and its power of absorbing X-rays of a given quality. This cause operates through the absorbing action of the atoms of which the crystal is composed. The form of the spectrum is also influenced by the circumstances of its production. The characteristic rays always occur in exactly the same place, but their relative intensities with respect to one another and the general radiation are modified by such causes as thickness of glass of bulb, width of slits, general form of X-ray bulb, state of exhaustion, nature of coil, and so on.

The case when atoms in the crystal itself are such as to be relatively opaque to portions of the incident radiation is considered. The ordinary spectrum obtained when rays from a Pt antikathode fall on a rock-salt crystal (100) shows three very prominent "peaks" or lines—for convenience called A, B, and C, corresponding to wave-lengths in descending order of magnitude. When the same rays fall on a ZnS crystal (111), the peak A is very largely increased relative to B and C. The rays which constitute the A peak penetrate the zinc with comparative ease, whilst rays constituting peaks B and C are very quickly absorbed by the Zn and consequently there is little opportunity for the energy to be reflected, since the bulk of it is taken in other ways such as the conversion of X-ray energy into kathode-ray energy. This hypothesis is tested further by using crystals of sodium arsenate and potassium bromide. In each case it is found that when the crystal contains atoms of atomic weight greater than 40 and the radiations divide themselves between those which lie on one side of a critical point and those on the other, the spectrum also shows a sharp division at that point, being far stronger relatively on one side than on the other. On the hypothesis that the magnitude of a radiation represented in the spectrum depends upon the amount of absorption of that radiation in the crystal, it should be expected that crystals containing only light elements would be very efficient reflectors, and this is actually found to be the case (*cf.* diamond). It is pointed out that the law connecting atomic weight with the amount of scattering seems to be one of simple proportionality; that is, the amplitude of the scattered wave is proportional to the weight of the scattering atom. A comparison of the spectra obtained by reflection from the diamond and a crystal of ZnS, which have the same construction, except that the two interpenetrating lattices in the one case are composed of C-atoms and in the other of S- and Zn-atoms—two elements of different atomic weights, shows that it is the weight alone and not atomic nature that determines the amount of scattering. E. A. O.

673. *Influence of Hardness of X-ray Bulb on Interference Effects with Crystals.* **W. Friedrich.** (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 69–73, Jan. 15, 1914.)—The bulb used was carefully regulated so as to be of constant "hardness" during the exposure. Zinc blende was used and the spots were examined with transmitted rays. The results showed that when the bulb was soft the spots corresponding to long wave-lengths were relatively stronger than when the bulb was hard. E. M.

674. *X-ray Patterns of Triple Symmetry.* **P. P. Ewald.** (Phys. Zeitschr. 14. pp. 1038–1040, Nov. 1, 1913.)—Shows that Laue's condition for the occurrence of 12 simultaneous interference patches [Abstract No. 90 (1914)] can be derived from a cubical structure without reducing it to a hexagon. The direction cosine of an interference ray with respect to the primary ray is—

$$1 - \tfrac{1}{2}(h_1^2 + h_2^2 + h_3^2)\lambda^2/a^2.$$

Now if $h_1^2 + h_2^2 + h_3^2$, which determines this expression, is put $= 8n$, the above sum of squares may also be written—

$$(h_1 + h_2 - n)^2 + (2n - h_1)^2 + (2n - h_2)^2.$$

This shows that it may be divided up into three squares in two different ways. Each such distribution yields a triplet of indices, which, on account of the equivalence of the co-ordinate axes, represents 6 points. Both distributions together gave 12 points. E. E. F.

675. *Röntgen-ray Spectra.* **M. de Broglie.** (Comptes Rendus, 158. pp. 177–180, Jan. 19, 1914.)—The author briefly describes the type of X-ray spectra obtained when a beam of rays, reflected from a slowly rotating crystal, is photographed [see Abstracts Nos. 243 and 244 (1914)]. Specimens are given of the photographs taken when beams of rays from Pt and antikathodes fall on a rock-salt crystal. A great improvement in the intensity of the spectra was observed by using rays from bulbs provided with lithium glass windows.

The spectra are all of the same character and show bands as well as fine sharp lines. The bands vary slightly with the nature of the antikathode. They are continuous and correspond to the very penetrating portion of the beam. It is suggested that these bands may be due to the electromagnetic waves produced by the stoppage of kathode particles within the crystal. So far, temperature and magnetic field have not been observed to affect these bands. In addition to these bands a large number of sharp lines are also present in all the spectra. The following table gives an idea of the type of spectra observed; it was obtained with a Pt antikathode; the angle of incidence is (90 — α) and *d* is the distance between the parallel reflecting planes of atoms in the crystal :—

	α.	$\lambda/2d$.	$2\lambda/2d$.	$3\lambda/2d$.
Border of intense band	4°·44′	0·0825	—	—
Border of less intense band	9 ·25	0·1636	—	—
Intense line	10 ·03	0·1746	0·36	0·522
Faint line	11 ·29	0·199	0·396	—
Medium line	11 ·44	0·203	0·408	—
Medium line	12 ·01	0·208	0·410	—
Medium line	13 ·00	0·225	—	—
Very intense line	13 ·46	0·238	0·475	—
Faint line	13 ·57	0·241	0·482	—
Medium line	15 ·44	0·272	—	—
Faint line	16 ·11	0·279	—	—
Medium line	22 ·11	0·378	—	—
Medium line (possibly 2nd order)	28 ·03	0·471	—	—
Medium line (possibly 2nd order)	29 ·13	0·488	—	—
Medium line	30 ·46	0·511	—	—

E. A. O.

676. *Observation of X-ray Spectra on a Fluorescent Screen.* **M. de Broglie** and **F. A. Lindemann.** (Comptes Rendus, 158. pp. 180–181, Jan. 19, 1914.) —It has been shown by Terada [Abstract No. 1668 (1913)] that the displacement of Laue spots by rotation of the crystal can be observed on a fluorescent screen. By allowing the reflected rays from a slowly rotating crystal to fall on a fluorescent screen rotating with double the angular velocity of the crystal, the present authors were able to make visible the lines in the spectra of the beams employed. This method is, however, necessarily much less sensitive than the photographic method described in the preceding Abstract; the effects were not observed except with tubes provided with lithium glass windows. It is suggested that owing to the persistence of impressions on the retina, all the lines in a spectrum might be observed simultaneously, if the crystal were rotated rapidly, say, about 10 times per sec. It is pointed out that if the bands observed in these spectra are due to the stoppage of kathode particles, the wave-lengths corresponding to them would be useful to calculate the diam. of the central part of the atom; the existence of two bands corresponds to two concentric layers causing the stoppage of the kathode particles. Supposing the acceleration constant and the fall of potential to be 80,000 volts, the numbers $\lambda = 4{\cdot}85 \times 10^{-9}$ and $9{\cdot}24 \times 10^{-9}$ (Cu) would correspond to a stoppage in a length 8×10^{-10} cm. and 4×10^{-10} cm., *i.e.* 4·5 % and 2·5 % of the atomic diam. This is of the order of magnitude of the diam. of the rings of electrons corresponding to the lines observed. E. A. O.

677. *Secondary X-rays.* **J. Laub.** (Phys. Zeitschr. 14. pp. 992–994, Oct. 15, 1913.)—Studies the connection between fluorescence X-rays and the electrons simultaneously liberated; the secondary rays generated when X-rays of different degrees of hardness fall upon the thinnest metallic sheets; and the change in the secondary radiation with the increase in the number of sheets and the angle of incidence. The measurements were made by determining by means of an electrometer the saturation current produced by the secondary rays in an ionisation chamber. Secondary rays could be produced even with the thinnest semitransparent gold- and silver-leaf, provided the primary rays fell upon them at grazing incidence (5° to 10°). The intensity depends greatly upon the angle when a characteristic radiation is produced. Cu emits a much harder characteristic radiation than that described by Barkla. The author also found radiations characteristic of iron and zinc, and Stokes' rule applies to these. The rays of Pt and Pb belong to Barkla's L series. E. E. F.

678. *Passage of X-rays through Metals.* **P. Knipping.** (Phys. Zeitschr. 14. pp. 996–998, Oct. 15, 1913.)—Studies the bearing of microcrystalline structure of metals upon the transmission of X-rays [Hupka, Abstract No. 1829 (1913)]. In the case of Pt-foil the surface is probably formed entirely of octahedral faces. [See also Keene, Abstract No. 1965 (1913).] E. E. F.

679. *X-ray Interference Patterns.* **E. Hupka.** (Phys. Zeitschr. 14. pp. 995–996, Oct. 15, 1913.)—Ascribes the striation of interference patterns to irregularities of the mineral surface analogous to "ghosts" in gratings. E. E. F.

680. *Sharpness of Röntgen-ray Interference Bands.* **E. Schrödinger.** (Phys. Zeitschr. 15. pp. 79–86, Jan. 15, 1914.)—A mathematical paper which reaches the following results:—(1) The interference bands become wider and more diffused as the temperature rises. In the way here defined, the breadth is proportional to the absolute temperature. (2) The central intensity of an interference pattern is inversely proportional to the absolute temperature. (3) The total quantity of radiation which produces an interference pattern is independent of the temperature. [See Abstracts Nos. 626 (1913) and 266 (1914).] E. H. B.

681. *X-rays and Metallic Crystals.* **E. A. Owen** and **G. G. Blake.** (Nature, 92. pp. 686–687, Feb. 19, 1914.)—A lump of copper (for instance) was cut in two, and one of the pieces heated up to a high temperature and then allowed to cool gradually, the other piece being left untreated. Beams of X-rays were allowed to fall at almost grazing incidence on the two newly-cut surfaces, and the reflected beam was examined on a photographic plate. It was found that the untreated specimen gave no definite reflection. In the case of the annealed specimen, however, spots were observed on the plate, indicating that there were now present in the metal crystals big enough to reflect quite an appreciable portion of the beam. The same results were obtained whether the surfaces were highly polished or badly tarnished.

On passing beams of X-rays through various metallic crystals, *e.g.*, antimony, zinc, aluminium alloy (50 % Al and 50 % Cu) Laue spots were observed on the photographic plates. Owing to the difficulty of procuring individual crystals of the metals symmetrical Laue patterns have not yet been obtained. The experiments show, however, that this method of investigating metallic crystals may prove very helpful to the metallurgist. E. M.

682. *Ionisation in Various Compounds of Carbon, Hydrogen, and Oxygen by Homogeneous X-rays.* **H. Moore.** (Phil. Mag. 27. pp. 177–187, Jan., 1914.)—Experiments were carried out on the ionisation produced by X-rays in compounds of light elements with a view to finding out if ionisation by X-rays is an atomic phenomenon. The results obtained by direct ionisation by X-rays gave no indication of the atomic character of the phenomenon, but they pointed out to the possibility that ionisation produced by corpuscular radiation might be atomic. Accordingly experiments were conducted to test this. The "corpuscular factor" for each of the vapours used was obtained—the corpuscular factor being the ratio of the ionisation produced in the vapour to that produced in air by the absorption of an equal amount of corpuscular radiation. On the assumption that ionisation by X-rays is effected by the liberated corpuscles, the amount of ionisation produced by the X-ray beam directly, divided by the corpuscular factor, gives in each case the amount of corpuscular radiation from the vapour, after a correction is applied for the corpuscular radiation from the hydrogen which is mixed with the vapour to bring the pressure up to atmospheric. From the values of the corpuscular radiation in the case of ether and methyl formate are deduced the "atomic" corpuscular radiations of carbon and oxygen. These are found to be 0·62 for oxygen and 0·20 for carbon. Assuming these to be the atomic corpuscular radiations of these elements when present in other compounds, and that the atomic corpuscular radiation of hydrogen is a negligible quantity, the calculated values of the corpuscular radiations in all the other compounds investigated were found to agree very closely with those observed by experiment. Hence the corpuscular radiation obeys an atomic law; the ionisation produced by X-rays is approximately atomic, because the corpuscular factor is very nearly unity in most cases.

E. A. O.

683. *Absorption of β-Rays.* **H. Starke.** (Phys. Zeitschr. 14. pp. 1087–1088, Nov. 1, 1913.)—Discusses the dependence of the absorption of β-rays as observed by means of an electrometer upon the relative positions of the preparation, the absorbing screen, and the electrometer or ionisation chamber. The apparent absorption is influenced by the secondary radiation produced by the original rays. These are best allowed for by placing the screen next the ionisation chamber and cutting off the direct β-rays transmitted by the screen. Under those circumstances only the diffused rays are effective.

E. E. F.

684. *Excitation of γ-Rays by β-Rays.* **H. Starke.** (Phys. Zeitschr. 14. pp. 1083–1087, Nov. 1, 1913.)—All the β-radiation issuing from a mesothorium preparation, then falling upon a metallic screen, excites γ-radiation of an intensity amounting to about one-thousandth of the proper radiation of the mesothorium. This figure assumes a radiation equal in all directions. The experiments only cover that portion of the γ-radiation which is not perceptibly enfeebled by 8 mm. of Al. The γ-radiation was determined from the ionisation current in a lead-covered ionisation chamber, as indicated by the charging-up of an Edelmann string electrometer. E. E. F.

685. *Registering the Emanation Content of the Soil-air at Potsdam with the Benndorf Electrometer.* **K. Kähler.** (Phys. Zeitschr. 14. pp. 27–31, Jan. 1, 1914. Extract.)—The mean absolute value of the emanation-content, at 0 to 1½ m. depth, for 289 days is given as $0{\cdot}22 \times 10^{-7}$ e.s. unit per cm.^{3}.

The highest hourly mean value registered is $0{\cdot}500 \times 10^{-7}$ in Feb., 1911, the lowest $0{\cdot}012 \times 10^{-7}$ in April, 1912. The amount of radio-active emanation in the unsaturated depths of the soil-air is greatest in summer and least in winter. It seems that with stronger heating of the soil more emanation passes from the saturated to the unsaturated layers, and, consequently also, from the unsaturated layer into the atmosphere. The emanation-content of the unsaturated layer shows the same yearly fluctuations as the electrical conductivity of the air. During any one day there appears to be a double period; a chief maximum occurring at 7 p.m. and a less important one at 6 a.m.; the chief minimum occurring at midday and another shortly after midnight. The dependence on alterations in atmospheric pressure is so regular that this must be looked upon as the chief cause of variations in the emanations. In all months the highest emanation values are obtained with rapidly falling, and the lowest with quickly rising barometer. In Munich a sucking action of the wind has been noticed, the emanation-content being greater with a strong wind. The sun's rays also promote the entry of the emanation into the atmosphere. A. E. G.

686. *Radio-activity of Japanese Hot Springs.* **H. Ikeuti.** (Mathematico-Physical Soc., Tōkyō, Proc. 7. pp. 176–180, Nov., 1913.)—Several springs were examined, and the mean emanation content per litre found to be about 100×10^{-12} curie for the water and 600×10^{-12} curie for the issuing gas. It was noticed that the emanation content of the water showed considerable fluctuations with time. The mean temperature of the springs was 45° C.
E. M.

687. *Radio-activity of the Waters of Spa.* **E. Gerard** and **H. Chauvin.** (Assoc. Ing. Él. Liége, Bull. 13. pp. 512–554, Nov., 1913.)—All the sources show marked radio-activity. The results are given in the form of tables.
L. H. W.

HEAT.

688. *Absolute Expansion of Fused Quartz down to the Temperature of Liquid Hydrogen.* **K. Scheel** and **W. Heuse.** (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 1–3, Jan. 15, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—In earlier communications [see Abstract No. 689 (1908)] observations by the Fizeau method on the expansion of two specimens of fused quartz, one by Heraeus and the other by Zeiss, between —190° and +100° C. were described. These observations together with others over the same temperature-range made upon a specimen from the Silica Syndicate are tabulated, and further observations upon the Zeiss specimen down to the temperature of liquid hydrogen are described. The original apparatus is modified so as to diminish the heat conduction into the bath. With this modification the specimen could be kept at the observation temperature for an hour, during which time the fringe system did not move. The earlier observations showing a minimum length in the neighbourhood of —80° C. are confirmed, and the extended results from —190° to —253° agree well with those extrapolated from the original formula. Reference is made to a paper by C. L. Lindemann [Abstract No. 333 (1912)] in which the expansion of various metals down to low temperatures was determined by comparison with fused quartz on the assumption that the total expansion of the quartz from —253° to +20° C. was zero. The authors point out that by using the present determinations of the expansion of fused quartz the values of a/C_v, the Grüneisen relation, depart from the values given by Lindemann by as much as 30 per cent. With copper and silver the values at various temperatures are in better agreement, but with Pb and Al the agreement is not so good. F. J. H.

689. *Thermal Conductivity and Specific Heat of Granite and Basalt at High Temperatures.* **H. H. Poole.** (Phil. Mag. 27. pp. 58–83, Jan., 1914.)—The paper is a continuation of the author's earlier work on the determination of the thermal conductivity of rocks at high temperatures [Abstract No. 1720 (1912)]. Modifications are described by means of which greater accuracy and ease of working are attained, the most important of these being the use of specimens of greater ratio of length to diam., an automatic regulation of the furnace temperature, and a new type of cement rendering it unnecessary to heat the specimen to a high temperature before making observations. Further measurements are made on the conductivity of granite, and show that the first heating to 500° produces a fall in the conductivity from nearly 6×10^{-3} to less than 4×10^{-3}, the value rising again to $4{\cdot}7 \times 10^{-3}$ on cooling. Subsequent observations show little further permanent alteration; they give a linear variation with temperature represented by the formula, $k = (4{\cdot}68 - 0{\cdot}00195\theta) \times 10^{-3}$. These values agree fairly well with the previous determinations, the chief difference being the straightness of the k, θ line. The initial permanent alteration in the conductivity is regarded as being due to the development of cracks on heating, arising from the unequal expansions of the mineral constituents. Experiments made with basalt show that during the first heating the conductivity rises slightly up to about 200°, this rise being followed by a small permanent fall upon further heating to

400°, the final value being about 4×10^{-3}. Subsequent results with the same specimen show a slight rise in the conductivity from 100° up to 270°, beyond which it remains constant at 4×10^{-3} up to 600°, there being now little permanent alteration. The difference in character of the curves with basalt and granite, which difference is confirmed in the paper by an additional experiment on the relative conductivities, is attributed to a coarse system of cracks present in specimens of basalt, but not in granite, and almost certainly formed during the original cooling and contraction of the rock. These cracks partially close when the rock expands, and thus cause an increase in the conductivity. The cracking upon heating which occurs in the case of granite is almost absent in the case of the finer-grained basalt, which accounts for the absence of the large initial permanent decrease in conductivity. Measurements of the specific heats of the rocks at various temperatures are also made by carrying out observations of their rate of cooling or their rate of heating in the furnace when no current flows through the axial wire. For granite the mean values for the several series of results obtained are given by the formula: $S = 0{\cdot}158 + 0{\cdot}87 \times 10^{-3}\theta - 0{\cdot}35 \times 10^{-6}\theta^2$. This gives a value at 56°, about 8 % lower than the value obtained by Joly with the steam calorimeter. The observations with basalt are represented by the formula $S = 0{\cdot}188 + 0{\cdot}265 \times 10^{-3}\theta - 0{\cdot}25 \times 10^{-6}\theta^2$, which gives a value at 56° in excellent agreement with Joly's value. F. J. H.

690. *Specific Heat of Air at Constant Pressure.* **L. Holborn and M. Jakob.** (Preuss. Akad. Wiss. Berlin, Ber. 8. pp. 213–219, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—An account is given of measurements made by the authors of the variation with pressure of the specific heat of air at constant pressure. The Callendar continuous-flow method is adopted. The air, which is compressed by a four-cylinder compressor driven by an electric motor, passes at air temperature into the strong-walled nickel steel calorimeter and is heated partly by an electric heating coil within, and partly by conduction from without to a temperature of 100° C. The calorimeter is surrounded by a rapidly circulating oil-bath, which is also provided with an electric heater to supply the heat conducted into the calorimeter at the cold end. This oil-bath keeps the surface of the calorimeter at a uniform steady temperature, which is determined by thermo-couples arranged over its surface; it is separated by a small air-space from a surrounding steam heater. The net heat-loss as the air passes through the calorimeter is eliminated in the usual way by taking observations with various rates of flow for the same rise of temperature. The results at atmospheric pressure are in satisfactory agreement with those of Swann and of Scheel and Heuse [Abstracts No. 1280 (1910) and No. 504 (1912)]. The variation with pressure measured up to 200 atmos. differs, however, enormously from that found by Lussana, but agrees remarkably well with that calculated by Linde's formula from recent experimental determinations of the cooling effect at various pressures.

F. J. H.

691. *Specific Heats of Air and Carbon Dioxide.* **J. R. Partington.** (Phys. Zeitschr. 14. pp. 969–973, Oct. 15, 1913.)—The ratio of the specific heats of air and of CO_2 as determined by Röntgen in 1873, are probably subject to a systematic error amounting to about 0·15 per cent. The author describes a new determination made by a combination of the methods of Lummer and Pringsheim and of Makower, involving the use of a Wollaston fibre 0·001 mm. in diam. and of duplicate leads. The resistance of the Pt-thermometer was

read off by means of a string galvanometer. The results for c_p/c_v, reduced to the state of ideal gas by means of Berthelot's equation, are—

Air	1·4032	CO_2 at 20°C.	1·3017
CO_2 at 0° C.	1·3084	CO_2 at 100° C.	1·2727

A list of former results obtained by other observers is also given.
E. E. F.

692. *Method of Heating Vapours to High Temperatures.* **K. Fredenhagen.** (Phys. Zeitschr. 14. p. 1047, Nov. 1, 1913.)—The vapours of alkali metals may be heated to white heat in tantalum tubes, thus avoiding the opacity produced by the vapours in glass and quartz. The tantalum tubes are heated electrically by means of a current of 70 amperes. E. E. F.

693. *Residual Rays of Long Wave-length.* **H. Rubens** and **H. v. Wartenberg.** (Preuss. Akad. Wiss. Berlin, Ber. 7. pp. 169–190, 1914.)—The residual radiation from the following substances is here dealt with: NH_4Cl, NH_4Br, TlCl, TlBr, TlI. Curves are reproduced showing the position of the maxima and minima. The selective absorption of quartz for the residual radiation from a number of substances is also considered, the wave-lengths varying from 50 to 150 μ. In the last part of the paper the formula of Madelung and Lindemann for molecular proper frequency is discussed. It is shown that the formula is in good agreement with experimental measurements. A. W.

694. *Fixing the Temperature Scale between* 0° *and* −193° *C.* **F. Henning.** (Ann. d. Physik, 43. 2. pp. 282–294, Jan. 23, 1914. Communication from the Physikal.-Techn. Reichsanstalt.)—In a previous communication [see Abstract No. 1169 (1913)] an account was given of the comparison of the readings of a number of Pt-thermometers with the hydrogen constant-volume thermometer at various temperatures between 0° and −193° C. The present paper describes the measurement by means of these thermometers of a number of fixed points within this range of temperature which are thus useful for the calibration of other Pt-thermometers. Such a calibration is necessary for low-temperature work since the Callendar formula does not hold below −40° C. and the readings cannot be represented by any simple formula. The following values were found :—

Oxygen, boiling-point at 760 mm.	−183·01°
Carbon dioxide, boiling-point at 760 mm.	− 78·52°
Mercury, melting-point	− 38·89°
Ethyl ether, melting-point	−123·6°
Carbon disulphide, melting-point	−112·0°
Chloroform, melting-point	− 63·7°
Chlorobenzene, melting-point	− 45·5°

These temperatures refer to the hydrogen constant-volume scale, initial pressure 780 mm. Correcting to the thermodynamic scale affects the boiling-point of oxygen only, this becoming −182·97°. F. J. H.

695. *Instruments and Methods used in Radiometry.* **W. W. Coblentz.** (Bureau of Standards, Bull. 9. pp. 7–63, March 15, 1913.)—The author presents a lengthy and exhaustive summary of the comparative advautages of

four types of instruments: the radio-micrometer, the linear thermopile, the Nichols radiometer, and the bolometer with auxiliary galvanometer. He describes in detail the possible methods of improving the sensitiveness of the radio-micrometer, by reducing the weight of moving parts, changing the period, and placing it in a vacuum. The Rubens thermopile is found to be only about half as sensitive as a bolometer; but it can be improved by using thinner wires in a vacuum. Thermopiles are not so well adapted as bolometers for instantaneous registration of radiant energy, but their greater steadiness is an advantage for measuring very faint radiation (*e.g.* in the extreme infra-red and ultra-violet). Bismuth-silver thermopiles are recommended on the ground of high sensitiveness and ease of construction. The Nichols radiometer is as sensitive as a bolometer, but its swing is longer. It is well adapted for measuring weak radiation, especially for the study of infra-red energy. Reference is also made to the difficulty of "drift," and a method is described of using a storage battery to furnish a constant current and overcome this defect. Another point is the design of instruments to be entirely unaffected by external magnetic fields. Finally the author describes a special bolometric outfit which combines, in a high degree, the various requirements mentioned above. J. S. D.

696. *Permanent Combustions in Conducting Media.* **L. Crussard.** (Comptes Rendus, 158. pp. 125–128, Jan. 12, 1914.)—Jouguet [see Abstract No 1172 (1913)] has given equations representing permanent combustions in a conducting medium. The author shows that it is possible to derive from the equation of conductivity a simple integral which simplifies considerably the investigations. T. H. P.

697. *Limits of Inflammability and Specific Retardation of Inflammability.* **L. Crussard.** (Comptes Rendus, 158. pp. 340–343, Feb. 2, 1914.)—The author discusses the equations governing permanent combustions and the limits of inflammability [see preceding Abstract]. T. H. P.

698. *Wien's Displacement Law.* **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 93–96, Jan. 30, 1914.)—A discussion, partly mathematical, as to the derivation of this law. E. H. B.

699. *Frequency Calculations and Relations between Elastic and Thermal Constants of Solid Elements.* **C. E. Blom.** (Ann. d. Physik, 42. 6. pp. 1397–1416, Dec. 23, 1913.)—The various formulæ for the atomic frequency which have been put forward by Einstein, Lindemann, Alterthum, and Benedicks are discussed, and then the conditions sought under which the frequencies obtained from the various formulæ all become equal. In this way certain relations between the elastic and thermal properties are obtained; for these reference must be made to the curves given in the original paper. L. H. W.

700. *Brownian Movements in Radiation Field.* **A. D. Fokker.** (Phys. Zeitschr. 15. pp. 96–98, Jan. 15, 1914.)—An analytical treatment from which it is concluded that a body, by the partition of energy supplied by radiation, acquires less than when it receives it by direct mechanical interchange.

E. H. B.

701. *Canonical Equation of State for Solids,* **K. Eisenmann.** (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 41–56, Jan. 15, 1914.)—An analytical discussion

on the basis of the Planck-Einstein expression for the energy of a solid body $L = h\nu(e^{h\nu/kT} - 1)^{-1}$, the Boltzmann conception of entropy $S = k \log W +$ constant, and the quantum hypothesis. An equation is obtained which simplifies to van der Waals' equation for sufficiently high temperatures. [See Abstract No. 885 (1918).] E. H. B.

702. *Quanta Theory of Gases.* **M. Planck.** (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 187–145, 1918.)—That the hypothesis of quanta has a significance for the mutual action of ponderable molecules may be concluded from the fact that the specific heat of condensed bodies decreases indefinitely with falling temperatures, whereas the compressibility retains a finite value. A severe test of the hypothesis may be looked for in the domain of the kinetic theory of ideal monatomic gases. If the temperature is sufficiently low, the gas behaves as an ideal gas even when saturated. The equation for the tension of saturated vapour is $\log_e p = -r_0/KT + \frac{5}{2}\log_e T + \log_e [(2\pi m)^{3/2}(k^{5/2}/eg)]$, where r_0 is the molecular heat of vaporisation at temperature zero. The last term is Nernst's "chemical constant." According to Sackur and Tetrode [Abstracts Nos. 880 and 1018 (1918)], $g = h^3$ where h is the action constant. The author deduces a law of emission of vapour, and shows in a provisional manner how it may be connected with the assumption that an atom only leaves the surface when its energy is a whole multiple of $h\nu$ ($\nu =$ frequency of vibration). E. E. F.

703. *Inversion Point for Liquid CO_2.* **A. W. Porter.** (Roy. Soc., Proc. Ser. A. 89. pp. 877–878, Jan. 1, 1914.)—In a recent paper by Jenkin and Pye [Abstract No. 1849 (1918)] observations of the Joule-Thomson effect for liquid CO_2 are given for various temperatures, and these show an inversion point at −28° C. This result is remarkable, as it implies that liquid CO_2 in this region behaves as a perfect gas. As, however, the results may be affected by the presence of traces of air, a new test for the inversion point is suggested, viz., that the ratio of the specific volume to the absolute temperature at this point should be either a maximum or a minimum. From the values of the specific volume at various temperatures and pressures given by Jenkin and Pye it is shown that a minimum value for v/T exists in the neighbourhood of −24° C., thus confirming the result found by direct experiment.

F. J. H.

704. *Radiation and Free Electrons.* **J. H. Jeans.** (Phil. Mag. 27. pp. 14–22, Jan., 1914.)—There is now very general agreement that for a system of matter and ether to give Planck's formula for the radiation in its final steady state, the motion of the system must be in some way different from that predicted by the classical laws of dynamics as summarised in the principle of least action.

The problem of finding a new system of laws which shall lead to Planck's formula is as yet unsolved. In our present state of knowledge the problem is largely one of guessing, and the lucky guess has not yet been made. On the other hand, a problem which admits of scientific and ordered treatment is the following: to examine at what exact point or points it is necessary to break with the old dynamics in order to obtain Planck's formula for the final partition of radiant energy. (1) There is nothing incompatible with Planck's formula in the classical laws of propagation of light in free ether. (2) There is nothing incompatible with Planck's formula in the classical laws of thermodynamics as applied to radiant energy and the ideal walls such as are imagined in thermodynamics. The attempt is then made to test the formula as applied to real matter. The simplest system of real matter which can be imagined is a single electron. And the author accordingly examines whether there is anything inconsistent with Planck's law in the classical laws of interaction between radiant energy and a single free electron. This is then treated mathematically.

The definite result then seems to emerge, that the departure from the classical mechanics is to be looked for in the fundamental equations of ether and electricity. Nothing so complicated as the structure of matter appears to be involved. It is not a question of modifying one's ideas on the build of atoms or molecules, but rather that we are called on to revolutionise views which have long been regarded as well established on the nature or meaning of electricity, the ether, or radiation. [See next Abstract.] E. H. B.

705. *Black-body Radiation.* **G. W. Walker.** (Roy. Soc., Proc. Ser. A. 89. pp. 393–398, Jan. 1, 1914).—The present paper was suggested by the discussion on radiation at the British Association Meeting of 1913. Planck's formula for the emission function E$_\lambda$ is $c^2h\lambda^{-5}/(e^{ch/k\lambda T}-1)$. This formula represents the observations for short and long waves at various temperatures with considerable closeness; and, if it is the correct expression, it is held by some to prove that the classical equations of dynamics and electrodynamics are at fault. The present author thinks the classical equations are not in much danger if properly applied, and has accordingly tried to trace the dynamical explanation of the experimental data. There must be many formulæ which will express the data as well as Planck's form. In the search for such, a clue soon appeared and led to the formula—

$$\phi(\lambda,\theta)=k\theta^5\frac{\lambda^4\theta^4}{[(\lambda^2\theta^2-a^2)^2+b^2\lambda^2\theta^2]^2}.$$

The function satisfies the following conditions. (1) It gives Stefan's law that the total radiation varies at θ^4, since—

$$\int_0^\infty\frac{x^4dx}{[(x^2-a^2)^2+b^2x^2]^2}=\frac{\pi}{4b^3}\qquad(a\neq 0\text{ and }b+).$$

(2) It gives Wien's law that the maximum radiation at any temperature occurs when $\lambda_m\theta=$ constant. In the formula here adopted $\lambda_m\theta=a$. (3) It gives the condition that the max. radiation at any temperature for this wave-length λ_m varies as θ^5. In the author's formula $\phi_{\text{max.}}=k\theta^5/b^4$. (4) It gives Rayleigh's formula for long waves $\phi=k\theta/\lambda^4$. These conditions are required by the experimental work of Kurlbaum, Wien, Paschen, Lummer and Pringsheim, and Rubens. The remaining point was accordingly whether the formula will fit the result of (say) Lummer and Pringsheim for short wave-lengths. For this b^2 could be equated to $4a^2$, and then the simpler form becomes $\phi=k\theta^5[\lambda\theta/(\lambda^2\theta^2+a^2)^4]$. It then follows from the data $\lambda_m\theta=a=2940$, where the units are λ_m in microns (10^{-4} cm.), and θ in Centigrade degrees absolute. Taking the experimental curve of Lummer and Pringsheim at 1450° abs., for which λ_m is practically 2 μ, the curve was calculated from the formula and fits the whole experimental curve excellently.

It is thus claimed that a formula has been found that fits all the data as well as, if not better than, Planck's. It is admittedly empirical, and may not stand alone. But in form it suggests what may be expected from a dynamical system with very heavy damping, and is shown to satisfy the electrodynamics of Larmor. More correct expressions for the vibratory motion than that of Lorentz and used by Planck are then put forward. These lead to equations which may be regarded as applicable to the behaviour of a molecule made up of a heavy, and so comparatively stationary, positive particle with a single electron revolving round it. The vibrations are of two types. In the first, which closely agrees with Lorentz's result, the damping is for optical purposes small, and the reduction of amplitude in the time between two collisions of a molecule with its neighbour would be small. But in the second type the frequency is enormous and the damping so great for optical purposes that the reduction of amplitude to a small fraction of its original value may be regarded as instantaneous. Just after each encounter the amplitudes of the two types may be regarded as comparable, but before the next encounter the second type will have been suppressed by almost instantaneous radiation, while the first type will not have suffered any great reduction. Is there not here a clue to the "quantum" theory and the characteristic Röntgen radiation? It is finally suspected that black-body radiation is determined not by the electron, nor by the positive particle alone, but by the joint action of the two. [See Abstract No. 520 (1912).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

706. *Kinetic Theories of Electronic Motion.* **H. A. Lorentz.** (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 2. pp. 152–156, 1913.)—Gives a summary of electronic theories of metallic conduction. Shows that only one species of free electrons can exist, and that these are separated from the atoms by a kind of dissociation. If X is the field due to an external electric field and a molecular field within a conductor in the direction x, then the electric current per unit sectional area is $i = \alpha d\mathrm{T}/dx + \beta(\mathrm{X} - \mathrm{K})$, and the thermal current is $w = -\gamma d\mathrm{T}/dx + \delta(\mathrm{X} - \mathrm{K})$. The quantities $\alpha, \beta, \gamma, \delta$ and K, which have definite values at a given point, must be determined by a kinetic theory of electrons. They can then be used to express the thermal and electrical conductivities, the thermoelectric power, the Peltier and the Kelvin effects. K is the value of X required to produce a uniform temperature throughout. The author does not believe that J. J. Thomson's explanation of diamagnetism by means of electronic orbits curved in the magnetic field can be carried through, as the distribution function in the magnetic field has the same form as outside it. E. E. F.

707. *Electrodynamics of Moving Ponderable Media and the Principle of Relativity.* **H. R. Hassé.** (Phil. Mag. 27. pp. 43–58, Jan., 1914.)—A mathematical and descriptive treatment of the equations of Lorentz, of Larmor, and of Minkowski. It is pointed out that Minkowski's equations are limited to the case of uniform translation though this is not always recognised. Towards the close of the article three interpretations of the symbols are discussed. The first leads to the equations of Minkowski, the second to those of Larmor or of Lorentz, while the third yield the equations of the field in the form adopted by G. T. Walker. But this last form does not completely satisfy the principle of relativity. E. H. B.

708. *Classification of Electromagnetic Fields.* **H. Bateman.** (Phil. Mag. 27. pp. 136–147, Jan., 1914.)—Analytical. E. H. B.

709. *Polarisation and Energy Loss in Dielectrics.* **A. W. Ashton.** (Phys. Soc., Proc. 26. pp. 43–53; Discussion, pp. 53–54, Dec., 1913.)—Discusses the relation between the coefficients in v. Schweidler's modification of Pellat's equation for the electric displacement in a viscous dielectric [see Abstract No. 650 (1908)]. It is shown that where the polarisation current of a dielectric under a steady e.m.f. is proportional to t^{-n}, the viscous capacity of any group of molecules with the same time constant of displacement is proportional to the $(1 - n)$th power of that time constant. It is hence shown that under an alternating e.m.f. of a frequency greater than about 1 per sec., the energy loss is proportional to the nth power of the frequency, and the viscous capacity proportional to the $(n - 1)$th power. An expression is obtained for the variation of capacity with change of frequency in the special case when $n = 1$. The experimental results of various investigators are shown to be in fair agreement with these deductions from the modified theory, but it is proposed

to carry out a series of tests of the constancy of n for a given dielectric at constant temperature but under varying frequencies. In conclusion, a brief *résumé* of Pellat's original theory is given. In the *discussion*, **A. Russell** said he thought Pellat's theory to be unsound and Schweidler's modification too artificial to be of practical value, while **W. H. Eccles** objected to it on the ground that an infinite number of exponential terms were required by it, accurately to represent the results of experiment. The **Author,** in reply, pointed out that a limit to the number of terms was fixed on the one side by the point at which the capacity ceases to be affected by an increase in frequency, and on the other by the time required fully to polarise the dielectric by a steady e.m.f. J. W. T. W.

710. *Electric Charge of Atmospheric Precipitations.* **G. C. Simpson.** (Phys. Zeitschr. 14. pp. 1057-1066, Nov. 1, 1913.)—Deals with the theory of thunderstorms [Abstract No. 848 (1910)] and with certain objections based by Schindelhauer upon data obtained at Potsdam. Shows that the latter are consistent with the assumption that the disintegration of a rain-drop liberates a charge of 0·005 e.s. unit, and that there is no evidence that thunderstorms are due to an influence effect as illustrated by the influence machine. E. E. F.

DISCHARGE AND OSCILLATIONS.

711. *Flame Couples.* **G. Moreau.** (Comptes Rendus, 157. pp. 1070-1072, Dec. 1, 1913.)—A continuation of previous work [see Abstract No. 517 (1914)]. The present paper deals with couples using two flames. Two Bunsen burners are placed together so that the flames are in contact: one is charged with a saline vapour. In each flame is placed a Pt electrode at about 1400° abs., bare, or covered with a deposit capable of emitting many corpuscles. The e.m.f. of such a flame-couple can be calculated from the formula $E = 0{\cdot}178 \log (n_1/n_2)$ volts, which is applicable when the two electrodes are covered with an oxide of one of the alkaline earths and are at 2000° abs.; n_1 and n_2 are the concentrations of the ions in the two flames. Various salts were used and the measured values of the e.m.f.'s agree well with the values calculated from the above formula. The series: bare Pt—pure flame—salt flame—covered Pt, and bare Pt—salt flame—pure flame—bare Pt are also dealt with. A. W.

712. *Recombination of Ions made by α-Rays.* **H. Ogden.** (Phil. Mag. 26. pp. 991-1001, Dec., 1913.)—It is known that the field required to obtain the full ionisation current in a gas in which a given number of ions are being produced each second is always very much greater if the ions are produced by α-rays than if they are produced by β-rays. Bragg and Kleeman attributed this difference to "Initial Recombination," and supposed that when ions are formed by α-rays the separation between the charges is less complete than when they are produced by β-rays, so that there is a marked tendency for the pair of ions to recombine before they can be separated by the field. Moulin, however, attributed the difference entirely to the difference in the initial distribution of the ions, in the case of α-rays the ions being produced in dense columns along the individual tracks of the α-particles, so that recombination proceeds more rapidly than in the case of the same number of ions distributed uniformly throughout the volume. The author, however, considers that the hypothesis of columnar ionisation does not seem capable of

explaining the whole matter, and in the present experiments the lack of saturation in ionisation by α-rays has been investigated for different gases. The Bragg "ionisation curve" apparatus was used and the current between two electrodes (one a wire gauze) 2 mm. apart was measured when α-particles traversed them normally, *i.e.* along the direction of the electric field. The current-potential curves were obtained, and compared with the relation deduced by Wheelock [Abstract 115 (1911)] on the basis of columnar ionisation. The results show that the latter theory does not apply, particularly in the cases of O, CO, and NH_3, which theoretically should give nearly identical saturation curves, whereas experimentally NH_3 gives lack of saturation to by far the most marked degree. The suggested reason for the deviation from the exact law is the presence in the gases of a small percentage of ions of small mobility. This receives support from the fact that the nearer the temperature of a gas is to its boiling-point, the more does the gas exhibit initial recombination. E. M.

713. *Analysis of Canal Rays.* **J. Stark.** (Phys. Zeitschr. 14. pp. 961–965, Oct. 15, 1913.)—Discusses the comparative merits of electromagnetic and spectroscopic analysis of positive rays. The spectroscopic method is better adapted to the discovery of positive rays of the higher valencies. This is due to the number of collisions of positive ions being necessarily greater in the spectroscopic method than in the electromagnetic method. These collisions, both in front of the kathode and behind it, give rise to ions of higher valency. In the case of heavy ions, like those of mercury, the advantage of numerous collisions for the formation of the higher valencies is evident even in the electromagnetic method. The latter method can be improved in this respect by making the pressure in front of the kathode as high as possible, preferably by the addition of a slightly dissipating gas like H or He. The capillary "canal" in the kathode must be made as narrow as possible so as to maintain the difference of pressure. E. E. F.

714. *"Field Canal Rays."* **J. Stark.** (Ann. d. Physik, 43. 1. pp. 47–48, Dec. 31, 1913.)—Arguments showing that the remarks of Wagner and Kutschewski, to the effect that the observation of "field canal rays" escaped the notice of the author, are not borne out by the facts. [See Abstracts Nos. 1007 (1910), 128 (1914).] A. E. G.

715. *Theory of Ionisation by Collision.* **J. Franck** and **G. Hertz.** (Deutsch. Phys. Gesell., Verh. 16. 1. pp. 12–19, Jan. 15, 1914.)—A continuation of previous work [see Abstract No. 310 (1914)]. The discussion is based on Townsend's theory. A. W.

716. *Ionisation of Gases by Collision with Low Electric Forces.* **F. W. Wheatley.** (Phil. Mag. 26. pp. 1034–1043, Dec., 1913.)—Townsend has shown that the process of ionisation by collision between the ions and molecules of a gas may be examined by investigating the currents between parallel plate electrodes when ultra-violet light falls on the negative electrode or when the gas is ionised by Röntgen or Becquerel rays. In the determinations which have already been made, the effect of the electrons for values of the ratio X/p larger than 60 has been obtained. The experiments described in this paper are undertaken with a view to finding the effects obtained by collision with smaller forces, and for that purpose it is necessary to measure the currents between plates at various distances apart to a high degree of

accuracy. A very constant source of radiation is therefore required for the experiments, and it would be practically impossible to obtain reliable results either with ultra-violet light or with Röntgen rays. The source of radiation used is polonium. The results show that the ionisation produced by α-rays is identical with that produced by Röntgen or Becquerel rays or by ultra-violet light, and has this advantage, that it produces a constant current. The apparatus is described in detail. The currents were measured by the zero method of Townsend with a condenser and a potentiometer. It is found that for values of X/p below 40 it was almost impossible to find the values of α/p when the pressure was as low as 9 mm. The value of α is so small that a very small error in observation would considerably affect the result. Also a 1% error in the e.m.f. would make an error of about 5% in α. With a higher pressure low values of X/p may very easily be found, and it is intended to extend the experiments by using large values of X and p in order to see for what range of pressures the formula $\alpha/p = f(X/p)$ is satisfied accurately. For $X = 80$ to 270 the numbers at 0·4 cm., 0·8 cm., and 1·2 cm. show that the initial ionisation is uniform for these distances and almost proportional to the distance, and that the ionising power of the α-particle does not diminish.

W. R. Barss claims to have discovered a characteristic difference between the behaviour of gases and vapours at higher pressures. A series of experiments is made using SO_2 with the apparatus described in order to test the results obtained by Barss. There is no evidence from the results obtained to show that the behaviour of SO_2 at higher pressures is at all inconsistent with the theory of ionisation by collision as developed for gases. The experiments differ from those made by Barss in the manner in which the radio-active matter is distributed. A. E. G.

717. *Failure of Photoelectric Effects with freshly-scraped Metal Surfaces when Gas capable of Reacting is excluded.* **K. Fredenhagen.** (Phys. Zeitschr. 15. pp. 65–68, Jan. 15, 1914.)—The theory is developed that photoelectric currents are produced on account of the presence of gases with which the metal can react. According to this theory, therefore, the current is due to the reaction between the metal, on which the light falls, and the surrounding gas; the immediate cause of the reaction being the light. **H. Küstner.** (Ibid. pp. 68–75, Jan. 15, 1914.)—Küstner attempts to prove the truth of the theory of photoelectric action as propounded by Fredenhagen. Full details of the experimental arrangements are given, together with the methods employed in making the measurements and the results of such measurements. These results, which have been obtained with zinc as the metal on which the light acts, show that when the surface of the metal is quite clean and all gas capable of reacting is excluded, there is no measurable photoelectric effect. It is certainly less than a thousandth part of that obtained under the usual conditions of experiment. The fatigue which occurs when gas capable of reacting is present, can be explained by reaction with adsorbed gases; the recovery, by diffusion of the reacting gas towards the zinc. Thus the velocity of reaction, and with it the strength of the photoelectric current, are regulated by the concentration of the reacting gas at the zinc. The pressure of neutral gas has no influence on the magnitude of the photoelectric effects so long as no ionisation by collision takes place. A. E. G.

718. *Photoelectric Effect.* **A. Hallermann.** (Zeitschr. wiss. Phot. 13. pp. 186–207, Jan., 1914.)—Describes research on the influence of temperature and the occlusion of gases on the photoelectric effect of metals, metallic

oxides and sulphides. The results may be summarised as follows:—Temperature has no influence on the photoelectric effect of either metals or metallic oxides. No relation could be found between the Hallwachs- and the Wehnelt-effect. At high temperatures the electrodes show no fatigue. This supports the conclusion that the fatigue is in many cases dependent on the absorption of gases. The sparking potential, *i.e.* the potential at which the spark passes between the electrodes without illumination, is much reduced when the temperature is increased. Metals and metallic oxides show similar behaviour at high potentials. The shape of the curve showing the connection between the potential and the photoelectric current is identical at high temperatures with that at ordinary temperatures. At first the current increases proportionally with the potential; then follows "saturation," and finally the current increases very rapidly through ionisation by collision. The substitution of sulphide for oxide has no influence on the magnitude of the photoelectric effect, and here also temperature shows no change. If a metal under investigation is used as the anode for a glow discharge, its photoelectric sensibility is lessened; if used for the kathode the sensibility is increased. The higher the temperature, the smaller is this effect, and it quite disappears at about 400° C. A distinct influence of the chemical nature of the gases could not be decided. According to Skinner a metal used as kathode gives out gas, and used as anode absorbs gas; also at higher temperatures the absorption decreases. Hence the results now obtained support the observations of Millikan and Winchester and of Ladenburg, that the occlusion of gases diminishes the photoelectric sensibility.
A. W.

719. *Long-wave Limits of the Normal Photoelectric Effect.* **R. Pohl** and **P. Pringsheim.** (Phil. Mag. 26. pp. 1017–1024, Dec., 1913.)—It was with the purpose of discovering the relations existing between the photoelectric properties of the illuminated molecules and their other characteristic properties, in particular their chemical behaviour, that the investigations on the photoelectric effect have been extended to a rather large number of elements. That the characteristic frequency of the selective effect, despite uncertainties in the position of the resonance maximum, is a material constant related to the atomic radius has been pretty certainly established. But in the normal effect as well, a constant which is characteristic of the material seems to enter. From the experimental data at present known, it may be regarded as established that the long-wave limit of the normal photoelectric effect furnishes a measure of the binding force between the electrons and the illuminated molecule. On the other hand, any attempt to formulate this relation quantitatively is met with the difficulty that the values for the long-wave limits of the normal photoelectric effect in the case of many metals and alloys are subject to variations as great as an octave and more. This difficulty is all the more real in that as yet we are not in a position to determine what influences, on and in the extremely thin bounding surface of the metal in which the light absorption takes place, are the determining factors in this displacement. A. E. G.

720. *Dependence of the Photoelectric Effect of Metals on the Surrounding Gas.* **G. Paech.** (Ann. d. Physik, 43. 1. pp. 135–164, Dec. 31, 1913. Extract of Dissertation, Dresden.)—The paper describes observations on the photoelectric effect of Pt in the gases, air, H, and CO_2—both damp and dry—these being made with a view to comparing them with the results of similar

experiments by Ullmann with Zn [Abstract No. 960 (1910)]. In order to get rid of effects due to absorbed gases the Pt plate is first heated in a vacuum electrically. The apparatus used for measuring the photoelectric effect is so constructed that the gas surrounding the plate can be changed very rapidly. In this way perfectly definite results are obtained. The relative effects of the gases are found to be analogous for the two metals, which seems to point to the fact that the surrounding gas exerts a definite primary influence on the photoelectric effect and that the effect of the metal itself is of secondary importance only. Experiments are also described in which the effects of the admixture of various vapours, viz. of methyl alcohol, acetone, chloroform, benzene, and of water are investigated. The effects of these are found to be in the order of their dielectric constants. Similar experiments on pure gases of relatively high dielectric constants give very large increases in the photoelectric effect, so that it seems that this effect is closely connected with the dielectric constant, a view already expressed by Hallwachs from theoretical considerations. J. J. H.

721. *Lecture Experiment to Illustrate Ionisation by Collision and to Show Thermoluminescence.* **F. J. Harlow.** (Phys. Soc., Proc. 26. pp. 55–60, Dec., 1913.)—A spherical discharge bulb is constructed with four leads passing into it carrying two small coils of Pt-wire coated with aluminium phosphate and lime respectively. These substances yield, when heated, abundant supplies of ions (positive from the phosphate, negative from the lime). The Pt-wires are placed near the surface of the glass and in the plane of the coil wound round the bulb for the purpose of producing the electrodeless discharge. The intensity of the discharge produced depends on both gas pressure and induced e.m.f. For any given e.m.f. the discharge can be excited over a given range of pressure only, and, within this range, its intensity increases to a maximum as the pressure diminishes, after which it decreases slightly, then becomes visibly intermittent and finally disappears altogether. By heating up either the lime or the phosphate to incandescence two noticeable effects are observed. First the intensity of the discharge, provided this is not too great initially, is considerably increased, and, secondly, the lower limit of the pressure-range over which the discharge can be produced is considerably extended. The first of these shows the increased ionisation in the gas caused by the collision of ions from the incandescent solid with the molecules of the gas. The second effect is an illustration of the fact that the sparking potential is considerably reduced by the presence of initial ionisation, since the discharge being intermittent is practically a succession of sparks. An interesting point demonstrated by the experiment is the well-known spreading of the discharge, as the pressure is diminished, on account of the increased diffusion of the ions at lower pressures. It is also found that the lime used possessed the property of displaying thermoluminescence. In an appended note it is stated that this phenomenon is due to the combination of the lime and Pt, and the conclusion is arrived at that thermoluminescence may be closely connected with the electrical activity of salts and oxides upon metals.

Further experiments are in progress. A. E. G.

722. *Dependence of the Photo-electricity of the Metal on the Gas, in Particular the Cause of the Strong Photo-electricity of Potassium.* **G. Wiedmann and W. Hallwachs.** (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 107–120, Jan. 30, 1914.)—An historical survey of the previous work upon the subject is first

given. For the present experiments the apparatus used is similar to that previously described. A special arrangement, a diagram of which is given, is used for successive distillation of the potassium. The results show that the great photoelectric activity of potassium can be explained by the exceptionally large absorption of gas by that body, the presence of the gas being a necessary condition of the remarkable photoelectric activity. The theoretical aspect of the question is also discussed. A. E. G.

723. *Conduction of Electricity in Extreme Vacua.* II. **J. E. Lilienfeld.** (Ann. d. Physik, 43. 1. pp. 24–46, Dec. 31, 1913.)—The subject is dealt with along the following lines:—Experimental expedients and the recovery of the vacuum. Comparison between series of experiments obtained at different times, 1909 to 1913. Experiments with fluid and solid hydrogen. Experiments with the high-vacuum valve. Comparison of results obtained with kathode of tantalum wire and with oxide-kathode. A general consideration of the results obtained. [See also Abstract No. 1318 (1910).] A. E. G.

724. *Behaviour of the Wehnelt Electrode in Different Gases.* **K. Fredenhagen.** (Phys. Zeitschr. 15. pp. 19–27, Jan. 1, 1914.)—It is found that nitrogen lowers the efficiency whilst the dependence on temperature continues constant. Oxygen also lowers the efficiency very much, and diminishes the dependence on temperature, especially at higher pressures. Hydrogen increases the effect and suppresses the temperature-influences almost completely. It appears, according to the results obtained with nitrogen, that the neutral gases lower the effect. An explanation of the results obtained with oxygen is offered. The failure of the temperature influences with hydrogen is difficult to explain and further research in this direction is necessary. Methane and coal-gas behave in a similar manner to hydrogen, while cyanogen acts like oxygen. A. E. G.

725. *Effect of Space Charge and Residual Gases on Thermionic Currents in High Vacuum.* **I. Langmuir.** (Phys. Rev. 2. Ser. 2. pp. 450–486, Dec., 1913.)—In this paper the author shows both theoretically and experimentally that the space charge in a space devoid of positive ions limits the current that flows from a hot kathode to a cold anode. Expressions are obtained giving the max. current possible for a given p.d. between parallel plate electrodes or between concentric cylinders. The experimental curves in which current is plotted against temperature follows Richardson's equation, viz. $i = a\sqrt{T}e^{-b/T}$, at the lower temperatures, but at the higher temperatures the current becomes independent of the temperature, reaching a kind of temperature saturation value; this value is dependent upon the voltage, being proportional to $V^{3/2}$. In the presence of gas, at pressures above 0·001 mm., and at voltages above 40 volts, there is usually sufficient production of positive ions to reduce greatly the space charge and thus to allow more current to flow than is indicated by the formulæ. At very low pressures the effect of most gases is, contrary to ordinary opinion, to reduce the electron emission from an incandescent metal, the effect being specially marked at low temperatures. The constant b of Richardson's equation is always increased, in the case of tungsten, by the introduction of O, N, CO, CO_2, or water-vapour. Argon, however, has no effect on either a or b, the values being the same as those in a perfect vacuum, viz. $a = 34 \times 10^6$ amps. per sq. cm. and $b = 55,500$. The presence of ionisation in the argon greatly reduces the space charge and large currents can be obtained with relatively small voltages. The effect of N in decreasing the thermionic current from tungsten depends on the voltage of the anode, the current with 240 volts being in many cases less than with 120 volts. With oxygen, the effect is independent of the anode voltage. The following theory seems to account for most of the observed phenomena and is apparently not inconsistent with any. The effect of gases in changing the saturation current is due to the formation of unstable compounds on the surface of the wire. In the cases observed the presence of the compound decreases the electron emission although in some cases it might cause an increase. The extent to which the surface is covered by the compound depends on the rate of formation of the compound and on the rate of its removal from the surface. The compound may be formed on the surface directly by the reaction with the gas as in oxygen, or by reacting with positive ions which strike the surface as with nitrogen. The compound may be removed from the surface by decomposition, evaporation, or kathodic sputtering (*i.e.* being driven off by the bombardment of positive ions). The results obtained by other observers are discussed, and it is pointed out that failure to observe the requisite conditions is probably the cause of their having found that the thermionic currents tend to decrease with increasing purity of the kathode and progressive improvement of the vacuum. As the result of his investigations the author concludes that the emission of electrons from an incandescent solid in a very high vacuum, *i.e.* below 10^{-6} mm., is an important specific property of the substance and is not due to secondary causes as has been recently supposed. F. J. H.

726. *Quantum Hypothesis and Electric Discharge from Hot Bodies.* **W. Wilson.** (Ann. d. Physik, 42. 6. pp. 1154–1162, Dec. 23, 1913.)—A theory of the electric discharge from hot bodies is here discussed, its basis being the quantum hypothesis of Planck. The formula thus derived accords with experimental results at least as well as the hitherto-used formula of Richardson. The theory brings the phenomenon of the electric discharge of hot bodies into relation with other phenomena, *e.g.* the discharges through the incidence of Röntgen rays and of ultra-violet light, whereas these have usually been regarded as essentially different from the discharge from hot bodies. [See Abstracts Nos. 1874 (1912) and 1985 (1913).] E. H. B.

727. *Law for Conduction through Gases in Cylindrical Fields.* **V. Schaffers.** (Comptes Rendus, 157. pp. 1417–1419, Dec. 22, 1913.)—The paper deals briefly with two empirical formulæ advanced by the author which give the connection between the current density and potential in a gas contained between concentric cylindrical electrodes, the inner of which is covered with an ionised layer. The formulæ, the applicability and limitations of which are discussed, are considered to be more satisfactory than that deduced by J. J. Thomson. F. J. H.

728. *Healing Effects at the Anode in Vacuum-tubes.* **B. Hodgson.** (Phil. Mag. 27. pp. 189–202, Jan., 1914.)—In a previous communication the author showed that the energy communicated to the anode during discharge in air was approximately proportional to the current through the tube. The experiments were made with gas pressures 2·7, 1·05, and 0·63 mm. The experiments here described have been carried out over a large range of currents and pressures in oxygen. The apparatus used was that previously described [see Abstracts Nos. 1187 (1913) and 141 (1914)]; the method of experimenting is slightly altered. Instead of allowing the anode to rise to that temperature at which the loss of energy by radiation is equal to the gain from the bombardment of negative carriers, the rise in temperature in a definite interval of time is measured, and a correction for loss by radiation applied. This method is found to yield results much more quickly with only a small loss in accuracy. The anode used is of lead, and has a heat capacity of 2·2 gm.-cals. When energy supplied to the anode per sec. is plotted against current for constant pressure, a linear relation exists at the pressures used. For lower pressures the curves are of a different type. For small currents proportionality exists between current and energy, and then, as the current increases, the energy communicated to the anode actually decreases and falls to a minimum value, after which a quick rise is obtained. If the mean potential through which an ion falls be plotted against pressure with constant current the curves all show a pressure-range from 2 to 4 mm. in which the energy given to the anode is approximately constant. As the pressure is reduced the energy per ion increases to a maximum at about 1·5 mm. pressure. It then falls to a minimum whose position and value vary with the current, and after this minimum a rapid rise is obtained for lower pressures. Neglecting distortions with short distances the energy given up to the kathode is independent of the length of the distance between the electrodes. This agrees with the assumption that the bulk of the positive ions originate in the negative glow. Were any produced in the space nearer the anode, the energy given up would increase with the distance between the electrodes. In the case of the anode an increase in the distance between the electrodes is accompanied by an increase in energy. Though the curves obtained showed a tendency to reach a maximum, none was reached even with a length of discharge of 24 cm.

The mechanism of discharge is discussed in the light of these results.

A. E. G.

729. *Short Spark-gaps between Metals.* **E. Taege.** (Phys. Zeitschr. 14. pp. 1041–1042, Nov. 1, 1913.)—Studies the influence of metal and gas on the quenching of sparks in a gap common to two closely coupled but non-syntonic circuits. The quenching is greatly increased by shortening the spark-gap. It is greatest in the gases of highest thermal conductivity and ionic mobility, the series of increasing action being Cl, Ni, air, O, NH_3, CH_4, coal gas, H. Chemical action between gas and metal is of no account, but those metals show the greatest quenching action which have the lowest electronic emission. Ca and Mg quench feebly; Al, Ni, and Zn a good deal better; and Ag, Pt, Cu, and brass best. Analysis of the sparks by Feddersen's mirror showed an afterglow in the case of Ca, Mg, Zn, and Sn, and stray discharges in the case of Mg and Ca. The thermal conductivity of the metal has no influence on the quenching.

E. E. F.

730. *Explosive Luminous Phenomenon in Rarefied Nitrogen.* **J. de Kowalski.** (Comptes Rendus, 158. pp. 625–627, March 2, 1914.)—According to Strutt, active nitrogen is formed by high-frequency discharges in the rarefied gas, especially when the latter is free from oxygen. Neither Comte nor Tiede, however, was able to obtain the active gas unless traces of oxygen were present. The results of the author's experiments confirm Strutt's assertion and bring to light a phenomenon not previously described. The purified nitrogen being enclosed in a flask with two stout copper ribbon spirals passing round the middle, the production in the spirals of very powerful high-frequency currents is accompanied by an annular luminous phenomenon determined by the induced field. When the pressure under which the nitrogen is subjected to the oscillating discharge is less than 5×10^{-4} mm., the appearance observed depends on the intensity of the induced electric field: (1) A relatively feeble field gives an annular discharge, the spectrum of which is composed of that of nitrogen together with a very faint mercury line, $\lambda = 546$; the latter is scarcely perceptible when cooling in liquid air is resorted to. (2) A very intense electric field gives a number of concentric rings of different colours, with which correspond distinct spectra. The Hg spectrum appears very sharp and is but slightly weakened by liquid air; this contamination of the gas by the mercury of the pump is, as was pointed out by Wachsmuth, very persistent. If, in case (1), the current is interrupted, the gas exhibits an orange phosphorescence for some minutes, as was described by Trowbridge and by Strutt; its spectrum corresponds with that of Strutt's active nitrogen. But interruption of the strong current is immediately followed by slight luminous explosions in the gas. The latter becomes far more highly illuminated in this phase than in the subsequent phosphorescence of the nitrogen, its colour being an intense bluish-violet. In 1898 Threlfall found that, under the action of discharges between a mercury and another electrode, an explosive nitride is formed in nitrogen, while the same nitride is formed under the action of Strutt's active nitrogen. The above phenomenon is doubtless also due to the formation of this nitride. As little as 10^{-9} mgm. of Hg is required to show the lines of this metal in the spectrum of the luminous phenomenon resulting from these explosions. T. H. P.

731. *Reflection of Electromagnetic Waves by Gratings.* **W. Arkadief.** (Russian Physico-Chemical Soc., Journ. 45. pp. 45–60 [Physical Part], 1913.)—The author has investigated the energy, y, reflected at gratings composed of four thin wires. Experiment shows that for non-magnetic wires the value of $A = y_0 - y$ (where y_0 is the energy reflected for zero wire resistance), increases somewhat more slowly than the square root of its resistance, while A increases with the wave-length. Measurements on the influence of the material of which the wire is composed were also carried out by the method which makes use of a single inclined wire stretched between two crossed Hertz mirrors. It was found that in both cases there is a similar dependence of the value of A upon the resistance of the wire. Both methods show further, that the values A_1 for magnetic wires are greater than for non-magnetic ones of equal resistance. The quotients $q = A_1/A$ for iron, steel, nickel, and kruppin for different wave-lengths are given in a Table in the original; q appears, independently of the method used, to decrease at the shorter wave-lengths and seems to approach unity at wave-length 1 cm. This result of the disappearance of the magnetic quality with the shortest waves has already been referred to by the author in his paper on the absorption of electric waves at two parallel wires [Abstract No. 1732 (1913)]. L. H. W.

732. *Phenomena in Oscillation Circuits.* I. **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 16. 2. pp. 100–106, Jan. 30, 1914.)—This first part of the treatment of two circuits in which electric oscillations are occurring is confined to the rigorous calculation of the instantaneous alternating charges and currents under given coupling (magnetic or electric). [See Abstract No. 668 (1913).] E. H. B.

733. *Disturbing Influence of Walls of Room on Measurements of Wave-length and Decrement of Short Electric Waves.* **M. Sjöström.** (Ann. d. Physik, 42. 6. pp. 1531–1560, Dec. 23, 1913.)—The paper shows how the reflection of the waves from the walls of the room in which measurements are made deforms the resonance curves and thus gives rise to wrong values of wave-length and decrement. The floor and ceiling of the room are the chief cause of the disturbance when the oscillator and resonator are parallel to them, and exercise an effect even when the oscillator and resonator are near each other and at some considerable distance above the floor. If the resonator is kept a constant height from the floor, and moved away from the oscillator, the intensity curve obtained shows periodic variations. The position of these variations agrees with that calculated from theory on the assumption that they are due to reflection. Throughout the experiments an oscillator of a new type is used. The sparks are very short and pass between flat silver plates between which a current of hydrogen saturated with alcohol vapour is passing. The radiated energy is great and constant in quantity. Mixtures of gases passing between the electrodes give much better effects than do the constituent gases of the mixture, when used pure. T. P. B.

734. *Effect of Ionisation of Air on Electrical Oscillations and its bearing on Long-distance Wireless Telegraphy.* **G. W. O. Howe.** (Phil. Mag. 27. pp. 213–215, Jan., 1914.)—This paper is a comment on the results obtained by Barton and Kilby [see Abstract No. 329 (1914)] on the effects of ionisation of air on electrical oscillations. The paper referred to cannot be taken to support Eccles' theory of the refraction of electromagnetic waves, since that theory requires that the ion be free from frictional resistance, whilst the experiments were carried out at atmospheric pressure. It is suggested that experiments in various vacua would have a better bearing on the theory. **E. H. Barton.** (Ibid. pp. 381–382, Feb., 1914.) T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

735. *Behaviour of Crystalline Selenium towards Luminous Radiations.* **P. Pignataro.** (N. Cimento, 6. Ser. 6. pp. 326–334, Nov., 1913.)—In order to study the action of a constant illumination on the resistance of selenium, which shows its max. variation in a fraction of a second, the author has utilised the deviation produced in the kathode rays in a Braun tube by the action of a magnetic field caused by the current traversing a selenium preparation. The results show that an infinite number of resistance curves may be obtained, since with any particular intensity of light there corresponds no single resistance. But leaving aside the alteration which may be produced in the sensitiveness of the cell by a very intense light, these curves should not surpass a certain limiting position depending on the maximum and minimum values of the light intensity. The max. variation of resistance for a sudden illumination is produced in about ½ sec.; in the succeeding period of 4 or 5 secs. the variation continues in the same direction but with diminished rapidity, the definite minimal resistance being attained only after several hours. The reversion of the preparation to its normal state after the suppression of the illumination proceeds similarly but occupies a greater period of time than is required for the attainment of the max. conductivity. Hence the laws according to which the resistance of Se decreases under the

influence of light and subsequently increases in the dark are not exactly the inverse one of the other. The times required for the conductivity to reach its max. value in the light and then its original value, increase with the intensity of the exciting light. T. H. P.

736. *Influence of Various Metals on the Thermoelectric Properties of Iron-Carbon Alloys.* **E. L. Dupuy** and **A. Portevin.** (Comptes Rendus, 157. pp. 776–779, Nov. 3, 1913.)—The number of alloys dealt with was sixty—(Fe, C 7 ; Fe, C, Cr 17 ; Fe, C, Mn 4 ; Fe, C, Al 7 ; Fe, C, Si 7 ; Fe, C, W 10 ; Fe, C, Mo 8)—and they were tested in two conditions : (1) After annealing 3 hours at 900–1000°, the cooling having lasted about 8 hours ; (2) after tempering from 1000° in water at 14° ; the initial temperature having been chosen high to cause solution of the carbides. The curves showing the change in the thermoelectric power indicate that in general this is diminished by tempering. The curves may be divided into two groups : (I) The metals, Mn, Si, Al, give a continuous curve resembling the first branch of the letter U. This resembles the behaviour of irreversible nickel-steels. The behaviour shown indicates the formation of solid solutions. (II) In metals such as Cr, W, Mo, there is first a rapid fall in the curve (indicating formation of a solid solution) and then a rise which seems to correspond to the saturation of the solution. The curves have the form of an horizontal S. The three metals are amongst those which, when added to an iron-carbon alloy rich in carbon give rise to carbides. Thus an idea may be attained of the limit of solubility in the solid state of the metals in the alloys of Fe and C. The carbides become isolated when saturation is attained, perhaps as a constituent of pearlite, perhaps as an extra-eutectic constituent. J. J. S.

737. *Bismuth Thermopiles.* **W. W. Coblentz.** (Frank. Inst., Journ. 176. pp. 671–676, Dec., 1913.)—This note describes experimental tests which contradict some theoretical views relative to the construction of thermopiles. It is not the case that the external resistance and the internal resistance of the thermopile should be equal for max. efficiency. The external resistance may be several times that of the internal without seriously affecting the efficiency. Some of Johansen's rules as to radiation sensitivity are only approximately true. The novelty of the Bi-Ag thermopile is the completely opaque receiver, while the symmetry of the hot and cold junctions is maintained. With various thermopiles it was found that one microwatt produces a rise in temperature of about $15° \times 10^{-5}$ C. above the surrounding air. This appears to be the most logical way to rate the efficiency of a thermopile. The most promising thermopile seems to be one having elements of pure Bi and an alloy of Bi + 6 % Sn, joined in series-parallel. J. J. S.

738. *Thermoelectric Forces of Bad Conductors.* **A. Weissenberger.** (Phys. Zeitschr. 15. pp. 105–107, Jan. 15, 1914.)—Determines the Peltier-effect in a Nernst filament against Pt, which was found by Shearer [Abstract No. 1102 (1912)] to be very high. The thermo-e.m.f. is negative (as of Fe against Cu) and amounts to 530 microvolts per degree at 1000° in case of a fresh filament, and about double that amount in the case of a burnt filament. Quartz glass shows a very similar behaviour, and in both substances there is no trace of polarisation. Soda glass, on the other hand, shows a positive e.m.f. accompanied by well-marked polarisation, probably due to ionisation of the glass. E. E. F.

739. *Polarisation of the Volta-effect by Gaseous Discharges.* **E. Wertheimer.** (Deutsch. Phys. Gesell., Verh. 15. 24. pp. 1838–1847, Dec. 30, 1913.)—Experiments are described in which the Volta-effect for each of the metals Pt, Au, Ag, Cu, Fe, Ni, Pb, Cd, and Zn is measured as soon as possible after its use as the kathode for discharges of short duration in air and oxygen. The discharge in both cases is found to produce a polarisation of the effect, the metals becoming more electro-negative ; a subsequent discharge in hydrogen, however, or the immersion of the metal in steam for a few seconds invariably diminishes the effect considerably. If the metal is left to itself the polarisation diminishes gradually, the original Volta-effect being regained in a few hours with some metals, with others in a few days. The p.d. between two plates of Cd, one of which had been subjected to the discharge in oxygen was found to be as much as 1·75 volts. The values obtained for the polarisation voltage generally do not show constancy for the same gas; they seem to depend upon the previous treatment of the metal and upon the conditions of the discharge which are not always reproducible. F. J. H.

740. *Influence of Diffusion on Conductivity of Ionised Gas in Plane Condenser.* **G. Jaffé.** (Ann. d. Physik, 43. 2. pp. 249–281, Jan. 28, 1914.)—A mathematical paper in which certain formulæ are derived, but no experimental data are yet extant for comparison with them. E. H. B.

741. *Induction of Two Circular Currents.* **E. Mathy.** (Journ. de Physique, 8. Ser. 4. pp. 970–974, Dec., 1913.)—In a former paper a formula was established for the evaluation of the coefficient of induction of two circular circuits. The author now gives a general solution of the system. C. P. B.

742. *Wheatstone Bridge with High-frequency Current.* **W. Hertwig.** (Ann. d. Physik, 42. 6. pp. 1099–1108, Dec. 23, 1913.)—The author continues Nernst's work on the application of high-frequency current in the Wheatstone bridge to the determination of dielectric constants [see Physical Soc. Abstracts Nos. 81 (1895), 408 (1897), and Science Abstracts No. 1517 (1904)]. The bridge forms part of a secondary circuit excited by the quenched-spark method ; it consists of four similar condensers, the two on each side having a common plate. In this way the self-induction of one pair of connecting wires is cut out. The other connecting wires are cut very short. The frequency employed is 10^6 per sec. A PbO_2-graphite combination is used as detector. The liquid of which the dielectric constant is required is placed in a specially-constructed vessel, which is connected in parallel with one of the condensers. The change in the capacity is balanced by inserting a glass plate between the plates of the corresponding condenser. If the liquid shows conductivity, resistance is inserted in parallel with the corresponding capacity. The special variable resistance employed is a thread of electrolyte in a capillary tube. Thus error due to change in self-induction or capacity by insertion of the resistance is avoided. T. P. B.

743. *Electrical Resistance of Mixtures of Xylol and Alcohol.* **N. Campbell.** (Phil. Mag. 26. pp. 1044–1053, Dec., 1913.)—Some further experiments have been made on the high resistances of mixtures of xylol and ethyl alcohol in glass tubes, to which reference has been made in previous papers [Abstracts Nos. 678 (1910) and 1104 (1912)]. The investigation was undertaken mainly with the object of obtaining information bearing on their use in

practice, but at the outset a point of theoretical interest was determined. It is to be expected that the mechanism of conduction in such a mixture should be similar to that in an electrolyte, but the previous experiments had shown that the conductivity of the mixtures differed from that of electrolytes in two particulars. First, the conductivity decreased with the temperature, like that of a metal; secondly, it appeared to be unaccompanied by polarisation. However, a little consideration shows that the second and most remarkable feature does not indicate that the conduction is not electrolytic. It appears that the easiest way to prepare a known resistance is to make the mixture out of commercial alcohol and xylol and then to measure its resistance and temperature coefficient. If a resistance of a definite number of ohms is required, the conductivity constant of the cell can be estimated from its dimensions: it can then be filled with a mixture of such conductivity that the cell will have the desired resistance. In this way a cell can easily be prepared with a resistance which does not differ from that desired by a factor of 3. If a closer adjustment is required, another mixture having the desired conductivity can be prepared from the same alcohol from the information contained in a given table. If a resistance of about 10^9 ohms is constructed and an accurate voltmeter is available, such a resistance can be compared with an accuracy of 0·5 %, with any resistance between 10^6 and 10^{13} ohms by means of the method shown. When it is desired to measure very small currents there seems to be no advantage in choosing a resistance of more than 3×10^{11} ohms; with such a resistance a change in the current of 3×10^{-15} amp. can be certainly detected. If a higher resistance be taken the conductivity of the insulation of the apparatus is apt to be comparable with that of the resistance, and if, as is usually the case, the currents measured are those due to radio-active rays, v. Schweidler's fluctuations prevent any increase in the accuracy of the measurement. These high resistances appear to provide the most convenient means of determining small currents of 10^{-10} amp. or less in absolute measure. They are both cheaper and easier to use than either standard capacities or quartz piezoelectrics. A. E. G.

744. *Silver Voltameter.* **E. B. Rosa, G. W. Vinal,** and **A. S. McDaniel.** (Electrical World, 63. pp. 373–374, Feb. 14, 1914.) [See Abstracts Nos. 501, 675 (1913).]—The object of the present work was to make a further comparison of the porous cup and Smith forms of voltameter, the results being expressed as the voltage of the Weston normal cell at 20° C. computed from the defined electrochemical equivalent of silver, 1·11800 mgm. per coulomb. The result of 156 deposits in the porous cup form is $1·01826_7$ int. volts, and the result of 55 deposits in the Smith form is $1·01827_4$ int. volts. The average deviation of a single observation from the mean is from 3 to 4 parts in 100,000. With other forms of voltameter the following results have been obtained: Siphon form, 1·01832; modified siphon form, 1·01835; Poggendorff form, 1·01830. It was learned from previous work that the effect of acid in pure electrolyte is to lower the mass of the deposit, and the authors give a quantitative relation between the amount of acid expressed in equivalents of HNO_3 per million (X), and the decrease in deposit also expressed in parts per million (Y). The relation is $Y = -4·5X + 0·02X^2$. A number of miscellaneous observations were made on the effect of various impurities, but mention need only be made here of the excessive deposits obtained when considerable CO_2 is present in the atmosphere above the voltameters. The authors think that both silk and filter-paper should be excluded from use in the voltameter. F. E. S.

745. *Weston Normal Cell.* **J. Pougnet, E. Segol, and J. Segol.** (Comptes Rendus, 157. pp. 1522–1525, Dec. 29, 1913.)—The authors find ultra-violet light to affect the e.m.f. of a standard cell. As glass is opaque to the ultra-violet rays the cell was set up in a vessel of quartz. It was placed 12 cm. from a 440-watt Cooper-Hewitt lamp and in 30 mins. 10 secs. its e.m.f. diminished from 1·0252 volts to 1·0192 volts. The temperature of the cell increased in the interval from 26° to 40° C., and when allowance is made for this the fall in e.m.f. due to the action of the ultra-violet light is calculated to be 0·0066 volt. The lamp was removed after the exposure of 30 mins. 10 secs. and the cell gradually increased in e.m.f. until at the expiration of 39 mins. (69 mins. 10 secs. from the commencement of the exposure) its e.m.f. was quite normal. The authors propose to continue the study. F. E. S.

746. *Reflecting Electrodynamometer.* **A. Palm.** (Zeitschr. Instrumentenk. 33. pp. 368–378, Dec., 1913.)—A description of a reflecting electrodynamometer of high sensibility in Hartmann and Braun's laboratory. The instrument has the moving coil and 2 fixed coils in sections, which can be used separately if desired. The moving coil has 7 turns, is of 18 ohms resistance, and has a self-induction of 4 microhenries. The fixed coils have 800 turns, are of 800 ohms resistance, and have a self-induction of 2 henries. The instrument is used (1) for indicating and measuring very small currents and voltages and their components, using an auxiliary current of adjustable phase in the fixed coils. (2) As a wattmeter for small power measurements. The voltage is across the fixed coils and the moving coil carries the current. (3) For measuring currents or voltages, the fixed and moving coils being in series. The moving coil is controlled by a Pt-Ni strip 7 cm. long, and the current enters and leaves by gold wires specially arranged. To compensate for the self-induction of the moving coil, a coil of a similar number of turns is arranged as nearly as possible coincident with the moving coil. F. E. S.

747. *A Rapid Thermopile.* **W. J. H. Moll.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 568–571, Dec. 27, 1913.)—A description is given of a thermopile designed to give rapid indications. In its construction a prompt heat-exchange and a wide surface exposed to radiation are secured, and thus a high degree of both rapidity and sensitiveness has been attained. The thermopile is built up of a great number of metal strips. Each of these consists partly of constantan and partly of copper, and is soldered at both ends to two copper bars. This constantan-copper strip can be exposed to radiation throughout its entire length. Then on account of the great difference in heat capacity of the two junctions one will attain a higher temperature than the other: the equilibrium of temperature is attained in a very short time owing chiefly to the good heat-conduction between the junctions. As Cu and constantan differ considerably in heat-conductivity the two metals which form the strip are taken of different thickness and length. Such elements can readily be combined to form a pile. In one such pile the total resistance was 9 ohms, and the radiation from a standard candle at a distance of 1 m. produced an e.m.f. of 18 microvolts, the current reaching 99 % of its definitive value within 1½ secs. J. J. S.

748. *Sensitive Thermopiles.* **E. S. Johansen.** (Phys. Zeitschr. 14. pp. 998–1000, Oct. 15, 1913.)—Gives further details of the author's type of vacuum thermopile, which was criticised by Coblentz [Abstract No. 1500 (1913)].

There are two constructions, one of which makes the "cold" junctions in the shape of solid copper blocks, while the other makes them as thin as the "hot" junctions. The latter form, originally devised by Rubens, has as constant a zero as the former, but the first type is $\sqrt{2}$ times as sensitive as the second. E. E. F.

749. *New Electrostatic Generator for High-tension Direct Current.* **H. Wommelsdorf.** (Elektrotechn. Zeitschr. 35. pp. 61–64, Jan. 15, 1914.)—The characteristic feature of the *Kondensatormaschine* lies in the condenser-like interleaving of the rotating and stationary discs and static fields; in operation the machine resembles a self-charging and discharging condenser. The rotating disc of an influence machine is subject to influence on one side only; electricity is drawn from the other side. In the present machine the rotating discs are influenced on both sides, and the charge is collected by steel wires dipping in grooves round the rims of the discs. At least twice the output of a corresponding influence machine is therefore obtained, but actually a condenser machine yields from 20 to 50 times as much electricity as a multiple-plate influence machine of the Holtz-Wimshurst double rotation type, owing to the very much smaller gap between the plates of the former. Owing to their dependence on atmospheric conditions, Wimshurst machines are ill-adapted to practical work. The author's 1907 machine—the forerunner of the present type—has been used extensively, and is characterised by the embedding of the sectors in vulcanised insulating material. This construction increases the current- and pressure-output, and improves the self-excitation of the machine besides increasing the life of the plates. In the condenser machine the sectors and the static field systems are similarly embedded. A completely enclosed and strongly built two-piece stationary shell contains the static field systems, between which rotate the influence discs; all the active parts are protected from dust and radiation losses. The rotary polariser is a simple rod so arranged that it can be used simultaneously to short-circuit the electrodes and the static fields. Two regulating series gaps are provided as well as a switch controlling the connection of the Leyden jars. An auxiliary gap on the baseboard serves for the withdrawal of high-frequency oscillating condenser-discharge current. The author points out the constructional weaknesses which limited the output and impaired the practical convenience of his earlier machines. To retain the advantages of vulcanite in other respects while avoiding its deterioration by ozone produced in and near the machine, the discs are made of vulcanite covered with a bakelite enamel (insoluble, hard, and highly polished). Either of two alternative connecting systems may be employed; these differ from the old Holtz connections, a variable high resistance being placed between two sectors formerly under the influence of a short-circuiting polariser. This resistance may be provided most simply by varying the distance between the polariser brushes and the ball collector. With Leyden jars disconnected, the discharge takes the form of innumerable ramifications forming a noisy arc over short gaps and retaining the form of a continuous flame discharge up to a gap of 220 mm. (modern 5-plate machine). Individual sparks can only be recognised when longer gaps are used. With the jars connected, a brighter and more crackly discharge is obtained without sacrificing spark-length. The polariser makes possible accurate starting and stopping of the effective current at any desired moment, and, if necessary, reversal of polarity. The chief applications of the new machine are to electrotherapy and Röntgen-ray work; the wide range of current, pressure, and output is an important advantage.

Rectified current is supplied, and the machine can be driven by hand if necessary. A Holtz-Wimshurst machine with two 55-mm. rotating discs provides up to 220 mm. spark-length and 70 milliamps.; a condenser machine with five rotating 55-mm. discs yields 350 mm. spark and 2500 milliamps. (3500 milliamps. with 7 discs). These data assume practical values for the polariser angle (> 30°) and speeds, etc. A condenser machine with one 26-mm. rotating disc provides about the same spark-length (175 mm.) as a Holtz-Wimshurst machine with eight 41-mm. rotating discs, and yields 350 milliamps. as compared with 110 milliamps. [See Abstracts Nos. 174, 793, 1027, and 1059 (1905).] R. E. N.

750. *Universal Magnetic Theodolite.* **N. Ogloblinsky.** (Terrestrial Magnetism, 18. pp. 185–192, Dec., 1913.)—In 1909 designs were prepared for a new magnetic theodolite involving the principles utilised in the Russian Imperial Navy, but adapted for land observations. The new instrument was tested at the Constantin Observatory at Pavlovsk in 1911, and in the course of a magnetic survey along the shores of the Bay of Finland, near Cronstadt, in 1912, it gave satisfactory results under difficult conditions. The chief feature is the employment of two deflectors, one on each side of the suspended needle system, the advantage of which arrangement had been pointed out by Kelvin, and first employed by Gray in the Glasgow Physical Laboratory in 1885. This seeming complication affords the following advantages:—It permits the use of shorter magnets and makes the series for H/M and Z/M more convergent; it abolishes the necessity of transporting the magnet from one side of the needle system to the other, and makes the measurements nearly independent of changes in the positions of the deflected needles within certain limits. Instructions are given for horizontal and vertical intensity determinations with the instrument. C. P. B.

ALTERNATING CURRENTS AND MAGNETISM.

751. *Wiedemann Phenomenon in Nickel Wires.* **T. Gnesotto** and **V. Mattioli.** (N. Cimento, 6. Ser. 6. pp. 348–374, Nov., 1913.)—The experimental arrangements used by the authors were similar to those previously described [see Abstract No. 937 (1912)]. The paper comprises: (1) The study of a group of torsion cycles obtained with a nickel wire subjected to constant tension, the circular field—the current traversing the wire—being kept constant and the longitudinal field varied cyclically. (2) The description of a group of torsion cycles obtained with the same wire at the same tension as before, the value of its longitudinal field being maintained constant while the circular field is varied cyclically. (3) The description of further groups of cycles obtained with the same nickel wire as above but subjected to a different tension, and with other nickel wires of different diams. and subjected to suitable tensions, first one and then the other of the two fields being varied. Detailed results and the corresponding curves are given in the original.
T. H. P.

752. *Intense Magnetic Field with Comparatively Small Electromagnet.* **H. Deslandres** and **A. Perot.** (Comptes Rendus, 158. pp. 226–235, Jan. 26, 1914.)—Two electromagnets are described which are capable of giving fields of 51,500 gauss. They differ considerably from the apparatus of Du Bois and Weiss. In the first form, the conical pole-pieces of a Weiss electromagnet are surrounded by a petroleum-tight box containing a magnetising coil made of

bare flat copper ribbon. A current of 24 amps. is passed through the main windings of the electromagnet, and one of 1100 amps. through the pole windings which are kept cool by means of a current of petroleum cooled to —80° C. The pole windings, which were 28 in number, gave 30,800 amp.-turns in a volume of 29 cm.^{3}, and the field due to these was 10,500 gauss, that caused by the main winding being 41,000, or altogether 51,500 gauss, as measured by the Zeeman-effect on the three blue Zn lines. In the second form, a soft-iron cylinder 10 cm. long and 22 cm. in diam. is cut in two by a plane parallel to its base, and a cylindrical cavity is cut out in which the bare wire windings are placed. A cylindrical hole is pierced along the axis of the iron for the optical purposes of the apparatus, and the windings are cooled by cold petroleum as in the first form. This form is excited only by the large current through the copper strip winding, and the whole apparatus weighs about 80 kg. For further particulars the original paper, which contains two full-page diagrams, should be consulted. G. E. A.

753. *The Ferromagnetic Property as a Function of the Wave-length.* **W. Arkadief.** (Russian Physico-Chemical Soc., Journ. 45. pp. 103–108 [Physical Part], 1913.)—In the author's experiments on the reflection of electric waves by thin wires in which λ was greater than 8 cm. and less than 80 cm., as also in his experiments on the absorption of waves by parallel wires, where the wave-lengths used ranged between 1·8 and 73 cm., a rapid diminution of the magnetic quality of magnetisable wires was noticed as the short-wave region was approached. With the aid of the results obtained by other workers it is now possible to take a general view of the change which the magnetisability undergoes with change of frequency of the magnetising field; such a view being obtainable from the curves given in the original.

At low frequencies we have a region of constant permeability; at greater frequencies there is a slow falling-off [$10^{-9} < T < 10^{-8}$ sec.; where $T = (\text{frequency})^{-1}$], and at still greater, in the region of the shortest electric waves ($1 < \lambda < 10$ cm.), the permeability falls very rapidly. The curves show further, that with iron at wave-lengths of a few mm., and with nickel already at wave-lengths of 2 cm. even, the electromagnetic phenomena in ferromagnetic metals occur with a permeability of unity, just as with the long-wave rays of Rubens. These results can be well explained on the hypothesis of the proper vibrations of the Weber molecular magnets. L. H. W.

754. *Thermal and Galvano-magnetic Effects in Bismuth and the Constants of Drude's Theory.* **P. Senepa.** (N. Cimento, 6. Ser. 6. pp. 303–325, Nov., 1913.)—According to Corbino [Abstract No. 1597 (1911)], Drude's formula relating to the Hall-effect [Abstracts Nos. 1276 (1900), 840 (1901)] does not correspond with the physical conditions under which such effect is determined experimentally. The author has applied Corbino's modifications of Drude's fundamental equations to the determination of the electronic constants of bismuth, calculations being made of coefficients of the Hall, Ettingshausen and Righi-effects, and of the conductivity. The results obtained tend to confirm Drude's electronic theory of metals, but it is necessary to avoid the use of the coefficient of the Righi-effect, the sign of which is incompatible with the theory; this was previously pointed out by Zahn [Abstract No. 3263 (1904)]. T. H. P.

755. *A Polymorphic Transformation in Fe-Co Alloys.* **R. Ruer and K. Kaneko.** (Phys. Zeitschr. 15. pp. 17–18, Jan. 1, 1914.)—The iron-cobalt

alloys undergo, within a certain range of concentration, a change from the γ to the α form, which is accompanied by evolution of heat and change of magnetic permeability. A cylindrical regulus from an alloy of 55 Fe and 45 Co was tested by the magnetometric method in an electric furnace, the specimen being 2 cm. long and 1·5 cm. in diam. Time-temperature and permeability-temperature curves are given for heating and cooling, and these show a discontinuity at 988° C.: in one case, the temperature remains constant at 988° for some minutes during heating and also during cooling; in the other case, there is a drop in permeability at the same temperature on heating, and a rise on cooling. Similar behaviour is shown by 60–40 % Fe and 40–60 % Co alloys, but not by 100 % Fe. The change is not explained by a simple alteration in specific heat, but rather by the transformation of a non-magnetic crystalline form into a ferromagnetic one, the process taking place at constant temperature with change of heat. G. E. A.

756. *Molecular Field and Maurain's Magnetising Action.* **P. Weiss.** (Comptes Rendus, 158. pp. 29–32, Jan. 5, 1914.)—With iron deposited electrolytically in a magnetic field, Maurain [Abstract No. 1112 (1902)] observed that the first layers of the metal are less magnetised than the later ones, these being subjected to a magnetising action by the former. This action may overcome that of a weak external field of opposite sign and may impose its sign on the lower layers. In order to ascertain the variation of this action with the distance, Maurain deposited on the magnetised kathode definite thicknesses of an indifferent metal such as gold, copper, or silver, and then observed the magnetisation of the newly-formed layers in an opposite field of 1·65 gauss. The magnetisation now in question cannot be attributed to an ordinary magnetic field, and since its action depends on the distance according to the same law as holds for the molecular field [see Abstract No. 557 (1914)], it is to be assumed that the two phenomena are identical. T. H. P.

757. *Magnetic Constants of Bismuth Amalgams.* **T. Gnesotto** and **M. Binghinotto.** (N. Cimento, 6. Ser. 6. pp. 335–347, Nov., 1913.)—Mercury, which has a coefficient of magnetisation $K = (-0{\cdot}191 \pm 0{\cdot}001)10^{-6}$, is taken as a standard of comparison for determining the coefficients of magnetisation at the ordinary temperature of a number of bismuth amalgams of different compositions. The magnetic constants were calculated by determining the force exerted on a mass of the substance of definite volume in the middle of the intrapolar space of a field created by exciting one of the two coaxial nuclei of an electromagnet. Increase of the percentage of Bi present from 0 to 0·8 causes a diminution in the value of $K \times 10^6$ from $-0{\cdot}191$ to a minimum, $-0{\cdot}188$; further increase in the proportion of Bi is accompanied by increase in the value of $K \times 10^6$, which reaches $-1{\cdot}460$ for pure bismuth. T. H. P.

758. *Variation of Ferro-magnetism with Temperature.* **P. Dejean.** (Soc. Int. Élect., Bull. 4. Ser. 3. pp. 11–38, Jan., 1914.)—A method of thermomagnetic research is described in which the induction in a bar or ring is graphed with the temperature, by Saladin's method, in such a way that the image of a luminous point describes a curve of which the ordinates are proportional to the induction and the abscissæ to the temperature. An alternating magnetising current of sine form was employed, and numerous heating and cooling curves are given for steels of different carbon-content.

In the *discussion*, **F. Robin** drew attention to the tendency to draw general conclusions from the results of the study of one property of a metal, and gave particular instances in which care was required in translating the effects. G. E. A.

759. *Hall-effect in Liquid and Solid Mercury.* **W. N. Fenninger.** (Phil. Mag. 27. pp. 109–112, Jan., 1914.)—Describes experiments for the detection and measurement of the Hall-effect in mercury, whence it is concluded that in liquid Hg the effect cannot exceed that with a coefficient 0·00002 e.m. unit and that in solid Hg the coefficient cannot exceed 0·000011 e.m. unit, which is about one-fourth that of tin. [See Abstract No. 1679 (1901).] E. H. B.

760. *Terrestrial Magnetism. Perturbations of the Magnetic Declination at Lyons* (*Saint-Genis-Laval*), *during the Third Quarter of* 1913. **P. Flajolet.** (Comptes Rendus, 157. pp. 1181–1182, Dec. 8, 1913.)—The working of the tramways has rendered almost impossible the absolute measurement of the vertical and horizontal components. The declination is little influenced by this cause of disturbance. In the original paper a table of observations is given, the reference figures having the following signification:—(0) Calm days; (1) Days with oscillations, very feeble, 1′ to 3′; (2) Oscillations feeble, 3′ to 7′; (3) Perturbations rather strong, 7′ to 15′; (4) Perturbations strong, 15′ to 30′; (5) Perturbations very strong, < 30′. E. O. W.

761. *Inequalities in the Distribution of Terrestrial Magnetism.* **P. Idrac.** (Comptes Rendus, 157. pp. 1488–1490, Dec. 22, 1913.)—The present paper is an extension of H. Wilde's work published in 1889, which deals with an instrument called the "magnetarium," designed to reproduce the phenomena of terrestrial magnetism. This instrument did not admit of investigation at high latitudes and in particular in the neighbourhood of magnetic poles, but the practical character of Wilde's ideas has led the present author to continue the work. The magnetarium itself consists of two quasi-spherical electric coils placed in the interior of a globe, the axis of one being parallel to that of the earth and the other inclined at 23° 30′ to this. By covering the marine surface with sheet iron a remarkable concordance was found between the magnetic elements given by a small compass needle on the globe and the same observed naturally—for example, the existence of the small oval area of zero declination in China, etc. The author has constructed a new apparatus, 50 cm. in diam., in which the current may be conveyed to the interior coils without disturbing the polar regions and so preventing their investigation. Wilde's results are for the most part confirmed, but the polar results are not in accordance with those of nature, the north pole being normal but the south widely divergent. All attempts to adjust the apparatus so as to yield accurate results have failed, since, when the correct position of the pole was established, the values for inclination became irregular. In the neighbourhood of the equator the results were well in accordance with facts. The author concludes that the magnetarium although very seductive in its simplicity of conception, is incapable of giving a complete account of terrestrial magnetism. It does, however, show that anomalies in magnetic distribution are very largely due to the effect of marine magnetism. The primary cause of this is difficult to establish in the present condition of the science, but may well be attributed to inequalities of the terrestrial core, or, at any rate, to a larger proportion of magnetic matter below the maritime regions. H. H. Ho.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

762. *Positive Charges of Atoms.* **J. Stark.** (Phys. Zeitschr. 14. pp. 965–969, Oct. 15, 1913.)—Certain substances which have no valency, chemically speaking, such as helium and argon, may yet be put into the form of bivalent or even trivalent ions as canal-ray particles. The author attributes this to the difference between the detachable chemical "valency electrons" and the more deep-seated electrons which can only be detached by impact, or by the actual penetration of a kathode-ray particle into the interior of the atom. For the same reason, the known range of valency of atoms may be considerably extended, as in the case of mercury, where valencies as high as 7 have been observed. E. E. F.

763. *Atomic Ionisation and Atomic Charge.* **F. Sanford.** (Science, 38. pp. 741–742, Nov. 21, 1913.)—From the atomic mass and velocity in electrolysis the author has made an estimate of the number of electrons in the atoms of H, Cl, Br, and I, and these numbers are now found to bear a constant relation to Kleeman's numbers representing the relative ionisations in these gases by either α-, β- or γ-rays. E. M.

764. *Decomposition of Hydrogen Sulphide by Radium Emanation.* **E. Wourtzel.** (Comptes Rendus, 157. pp. 929–931, Nov. 17, 1913.)—The experiments were made with the emanation from 330/mgm. of RaBr and two flasks charged with H_2S gas, the one kept at ordinary temperature, the other cooled down to −220°. The emanation produced a mist from which sulphur condensed; polysulphides were not observed; the hydrogen liberated was determined by immersing the flask in liquid air and passing the non-condensed gas into a burette. The rate of decomposition decreased in the course of an experiment; the pressure (2·2 to 1·4 atmos.) appeared merely to influence the absorption of the emanation by the gas; the rate of decomposition decreased as the temperature rose. The number of H_2S molecules decomposed per α-particle seemed to be 3·3 times the number of ions produced in air under the same conditions. Comparing his results with those of Duane and Scheurer on the decomposition of liquid water by the emanation, the author does not find equivalence. H. B.

765. *Method for Determination of Molecular Weights of Radio-active Emanations, with Application to Actinium Emanation.* **E. Marsden** and **A. B. Wood.** (Phil. Mag. 26. pp. 948–952, Dec., 1913.)—The method depends on the effusion of the emanation through a hole at pressures so low that the mean free path is large compared with the size of the vessels used. In such conditions $\frac{1}{4}\Omega A(N_1 - N_2)$ mols. will cross from one side of the hole to the other; $\Omega =$ mean molecular velocity, $A =$ area of hole, N_1 and N_2 are numbers of mols. of emanation per cm.^{3} on the two sides. If V_2 is the volume of the vessel into which the emanation effuses, this number $= \lambda N_2 V_2$, where λ is the disintegration constant. In the experiments N_1/N_2 is obtained from ionisation measurements, and the molecular weight deduced from the calculated value of Ω. The value for AcEm is found to be about 240. The

calculated value, however, depends on λ^2, and λ is only known as yet to within about 2 %. The value indicates, however, that if Ac is derived from the Ur series it must be produced by one of the higher members. E. M.

766. *Valency of Radium.* **H. Freundlich** and **G. v. Elissafoff.** (Phys. Zeitschr. 14. pp. 1052–1057, Nov. 1, 1913.)—The reduction of the electric osmose of water by electrolytes shows a well-marked dependence upon the valency of the ions, being much stronger in multivalent than in univalent ions. This suggests a method of determining the valency of an element which is only available in small quantities. The authors work out a method of observing the flow of the liquid past a bubble in a capillary tube. The amount of the kation need not exceed 0·01 or even 0·001 mgm. Experiments with RaBr put it in the same category as Mg or Ba salts, and its bivalence is thus corroborated. Experiments with actinium remained inconclusive. E. E. F.

767. *Question of Separation of RaD from Lead.* **C. Staehling.** (Comptes Rendus, 157. pp. 1480–1482, Dec. 22, 1913.)—RaD was mixed with $PbCl_2$, and it was found that in the Grignard reaction the ratio of RaD : Pb was not altered in either of the Pb reaction products:—

$$2PbCl_2 + 4C_6H_5MgBr = (C_6H_5)_4 Pb + Pb + 4MgBrCl.$$

[See Abstract No. 578 (1914).] E. M.

768. *Glow of Sulphur.* **W. H. Watson.** (Chem. News, 108. pp. 187–188, Oct. 17, 1913.)—The fact that, under certain circumstances, sulphur exhibits a "glow" or phosphorescence has been frequently recorded. The author's experiments furnish the following explanation of this phenomenon. When air passes over sulphur heated at a temperature below its ignition-point, the air becomes charged with sulphur-vapour, which separates as a mist or cloud of very small particles. It is the oxidation of this finely-divided sulphur which gives rise to the phosphorescence, but no evidence is obtainable in support of the view which has been advanced that the glow is accompanied by the formation of a lower oxide of sulphur, such as the monoxide, SO. T. H. P.

769. *Mechanical Stimulus to Crystallisation.* **S. W. Young** and **W. J. Van Sicklen.** (Amer. Chem. Soc., Journ. 35. pp. 1067–1078, Sept., 1913.)—In previous papers on this subject it has been shown that crystallisation in supercooled liquids may be forced at any temperature below the melting points, so that there exists no so-called metastable field in which crystallisation can be stimulated only by the addition of a crystal of the new phase. On the basis of thermodynamical considerations, Berkeley [Abstract No. 312 (1913)] arrives at the conclusion that a limit must exist to the supersaturation of a solvent with a solute, his experimental results confirming the view expressed above. The authors now describe experiments on the freezing of supercooled dust-free water by the impact of a hammer falling on an anvil from a gradually increasing height. It is found that the hardness of the impact surfaces increases with continuous use to a max. value, this change being accompanied by augmentation of the sensitiveness; the latter is brought back to its original value by repolishing. All the experiments were made at the maximum sensitiveness. The composition of the hammer and its size exert considerable influence on the results.

With a stellite hammer and anvil, water may be repeatedly frozen at a temperature rather less than 0·02° below its melting-point, so that if water possesses a metastable limit this lies at less than 0·2° below the melting-point. The following relation has been established: $(\sqrt{M} \times S - \Delta)\,\theta = \text{constant}$, where M is the mass of the hammer in gm., S the distance of fall in cm., θ the extent of supercooling in degrees, and Δ a constant having the value 8 for steel and 13 for stellite. T. H. P.

770. *Capillary Crystals of Iron-vitriol and Silver.* **O. Mügge.** (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 3. pp. 357–364, 1913.)—Capillary crystals of green vitriol sometimes develop from iron pyrites or marcassite, which are irregularly curved, but are sometimes composed of a single individual crystal. They have the appearance of having been squirted from an orifice and of having crystallised immediately beyond it. Similar capillary crystals of silver are formed when silver sulphide is heated to 180° in air or hydrogen, and less readily in indifferent gases. T. M. L.

771. *Liquid Mixed-Crystals.* **P. Gaubert.** (Comptes Rendus, 157. pp. 1446–1448, Dec. 22, 1913.)—Complete series of mixed crystals can be prepared from cholesterol propionate and ethyl anisalaminocinnamate from 10 : 0·5 to 10 : 16·66. The double-refraction of the mixtures for sodium light increases from $\omega - \epsilon = 0{\cdot}0177$ to 0·1009. This effect occurs in spite of the fact that the substance added has a positive instead of a negative double-refraction. T. M. L.

772. *Allotropy of Cadmium.* **I. E. Cohen** and **W. D. Helderman.** (Konink. Akad. Wetensch. Amsterdam, Proc. 16. pp. 485–489, Nov. 27, 1913.)—It was pointed out by Matthiessen and v. Bose (Poggendorff's Annalen, 115. p. 358, 1862) that cadmium becomes extremely brittle when heated above 80°. Previous experiments on tin and bismuth have shown that metals may exhibit excessive slowness in undergoing molecular changes at temperatures either above or below their transition-points, and such reluctance to undergo change is regarded as one of the reasons why the allotropy of these metals remained so long undiscovered. Similar behaviour is found by the authors in the case of cadmium. Their first experiments consisted in determining the densities of two samples of "Kahlbaum" cadmium pyknometrically. The changes in density produced by heating the metal at various temperatures for 24 hours, either in an atmosphere of CO_2 or in a dilute cadmium sulphate solution, indicate the existence of a transition temperature between 40° and 70°, and experiments with the dilatometer fix this temperature at 64·9 ± 0·1°. The expansion accompanying the transition of cadmium-α into cadmium-β at 64·9° explains the disintegration of Cd-wires at 80° observed by Matthiessen and v. Bose. T. H. P.

773. *Influence of the Principal Metallic and non-Metallic Additions on Normal Copper-Tin Bronzes.* **H. v. Miller.** (Métal, 2. pp. 63–72, 1912. Rev. de Métallurgie, 10. pp. 662–667, Dec., 1913.)—Using the method described by Wüst [Abstract No. 500 (1910)] the author has studied the effects of adding Co, Zn, Pb, Sb, Al, Si, Ni, W, P, and Mn, on the contraction of copper-tin bronzes. The strength, working properties and colouring power in a warm solution of liver of sulphur have also been determined and compared with the similar properties of a normal bronze containing 8 % Sn. Generally the coefficient of contraction of the normal bronze is taken as 0·7 %, but the figure repeatedly determined by the author is 1·5 %. A considerable quantity of zinc (10 %) has to be added before the coefficient of contraction is appreciably diminished. Co, Al, Si, Fe, and Ni increase the contraction. Strength is increased by Co, Ni, and Mn, but is decreased by Sb and excess of Zn. The machining properties are improved by adding 2 % of Sb or Pb, but deteriorated by Mn and Ni. The intensity of the patina formation is diminished by Zn and Al, but increased by the addition of Co, Ni, Sb, Fe, Si, and P. Ordinary bronzes have considerably lower solidification points than bronzes containing W, Ni, Fe, Mn, and Co. F. C. A. H. L.

774. *Researches on Manganese-Silver Alloys.* **G. Arrivaut.** (Rev. de Métallurgie, 10. pp. 1257–1263, Nov., 1913.)—The author has investigated the Mn-Ag system by thermal, microscopic, p.d., and chemical methods. Thermal methods show that the solidifying point of Mn (1235° C.) is lowered to 1180° C. by the addition of about 6 % Ag. Between 94 and 31 % Mn the temperature of deposition of solid remains constant at 1180° C. indicating the existence of two liquid layers in this region. From 31 to 20 % Mn the latent heat of fusion is so small that the solidifying temperature is not indicated on cooling curves. In all these alloys a reaction occurs at 980° C. between solid and liquid, resulting in the formation of the compound $MnAg_3$. Near the silver end of the series a feeble minimum is reached at 955° C. in an alloy containing 4 % Mn. The absence of an eutectic line indicates that Ag and $MnAg_3$ form a continuous series of solid solutions. Microscopic examination of the solid alloys confirms these views. Determination of the p.d.'s set up in an electrolyte consisting of a 10 % solution of manganese sulphate against a silver electrode depolarised with manganese dioxide also confirmed the existence of the compound $MnAg_3$ and indicated the existence of a continuous series of solid solutions between 0 and 20 % Mn. A number of the alloys were powdered and treated with 10 % hydrochloric acid. In every case a brilliant metallic residue was left. It had a sp. gr. of 8·81, was unaffected by the atmosphere of the laboratory, and was unattacked by solutions of sulphuric and hydrochloric acid except when the latter were hot and strong. Chemical analysis showed its average composition to correspond with the formula $MnAg_3$.

F. C. A. H. L.

775. *Brittleness in Lead.* **O. Bauer.** (Königl. Materialprüfungsamt, Mitt. 31. 7. and 8. pp. 357–369, 1913.)—Preliminary tests carried out at various temperatures showed that the resistance of lead sheets to bending slightly decreased up to 160° C. and then increased again up to 260° C. Cold bending tests carried out on lead sheets which had previously been heated for various periods at temperatures between atmospheric and 260° C. showed that the resistance to bending decreased by an amount depending upon both the temperature and time of heating. At 100° C. the reduction was relatively slight (from 22 to 17·8) after 24 days, and even after 41 days the value had only fallen to 17·1. At 260° C., however, the value fell to 12·4 in 10 days and after 17 days had become constant at 11·6. These results have been summed up in a solid model showing the relationship between time, temperature, and the resistance to bending. At the same time grain-growth has been followed by means of the microscope and planimeter. In general, the dimensions of the grains increase with both the time and temperature of heating. F. C. A. H. L.

776. *Constitution of Bismuth-Cadmium-Zinc Alloys.* **C. H. Mathewson** and **W. M. Scott.** (Int. Zeitschr. Metallog. 5. pp. 1–60, Nov., 1913.)—The authors criticise the results of earlier work on the constitution of the Bi-Zn series which furnishes a good example of limited miscibility in the liquid state. Their own results confirm those of Heycock and Neville and show that there is a region of limited miscibility in the liquid state, the concentrations of the two conjugate layers at the temperature of crystallisation (416° C.) being 99·35 and 86·8 atoms per cent. respectively of zinc. The liquidus curves of the Bi-Cd and the Cd-Zn series have also been redetermined. Cd appears to dissolve about 1·5 atoms per cent. Zn, but in the other cases solubility in the solid could not be detected by thermal analyses. In the ternary series about 100 alloys were prepared and studied thermally, the object being to establish the constitution throughout the temperature range of crystallisation without reference to the question of miscibility between liquid phases above this range. The results are summed up in an isothermal diagram which is discussed theoretically from a graphic potential standpoint. Addition of Cd to Zn-Bi alloys lowers the temperature of equilibrium between two liquid layers and Zn. At a critical temperature of 326° C. and a concentration of 6·9 atoms per cent. Bi, 57·1 atoms per cent. Cd and 46·0 atoms per cent. Zn, the two liquid phases mix in all proportions. A ternary eutectic is formed containing 44·3 atoms per cent. Bi, 54·1 atoms per cent. Cd, and 1·6 atoms per cent. Zn. F. C. A. H. L.

777. *Influence of Elements on Absorption of Carbon by Steel.* **R. R. Abbott.** (Amer. Inst. Mining Engin., Bull. 82. pp. 2389–2400, Oct., 1913.)—The results of 208 experiments on the carburisation (case-hardening) of various steels are used for the calculation of equations and plotting of diagrams to give the rate of carburisation (increase of weight) at 900° C. and 1000° C. Since they are sources of error in the form of equation selected, S, Mn, P, and Si were left out of the final solution and the steels high in silicon were not used in calculations involving more than two variables. Thus the equation for carbon-nickel steels at 1000° C. is $C/1·13 + Ni/39·5 + Wt./265 = 1$. This gives, for example, that a steel containing 3·5 % Ni and 0·20 % C. will absorb C as readily as a steel containing 0·30 % C and no Ni. The equations worked out for C, Ni, and Cr are: at 900° C., $C/0·56 + Ni/6·85 - Cr/53 + Wt./100 = 1$; and at 1000°, $C/0·56 + Ni/6·95 - Cr/30 + Wt./199 = 1$. These are not fully satisfactory when applied to practical interpretations; they would, for example, indicate that a pure iron would absorb 199 mgm. of carbon at 1000° in 10 hours, and 100 mgm. at 900°; as a matter of fact this is too low a value. Manganese at 900° is apparently without effect on the rate of carburisation, and at 1000° it increases with increase of Mn. The other results can only be fully appreciated with the aid of the diagrams and detail figures. The results for various series (Cr–V, Ni, C, and Si steels) show that the rate of absorption of C is lowered to the same extent in all except Si steels by an equal increase of C in the original steel. The relation between original carbon-content and rate of absorption is probably not a straight line. At 900° the effect of increase of original carbon-content in decreasing the rate of absorption is greater than at 1000°. F. R.

778. *Influence of Silicon on the Solubility of Carbon in Iron.* **G. Charpy** and **A. Cornu.** (Comptes Rendus, 157. pp. 901–903, Nov. 17, 1913.)—Five iron alloys containing about 2 % carbon and from 2·23 to 6·77 % Si were annealed at 100° C. for 8 hours and cooled very slowly in order to convert the whole of the carbon into the graphitic form. Small specimens were then cut, heated to various temperatures between 600° and 1000° C. and cooled rapidly. The resulting samples were then tested for total carbon and graphitic carbon contents. The results, which were confirmed by the determination of the Brinell hardness figures, indicate that addition of Si gradually diminishes the solubility of carbon in iron. With 4 % Si the solubility is nil up to 900° C., while with 7 % Si practically no carbon dissolves up to 1000° C. F. C. A. H. L.

779. *Influence of Copper upon Steel.* **G. H. Clevenger** and **B. Ray.** (Amer. Inst. Mining Engin., Bull. 82. pp. 2437–2475, Oct., 1913.)—The authors found it advisable in making their copper steel ingots in crucibles to kill for some time before adding copper, and to add Al before teeming. The carbon contents of the eight steels ranged from 0·44 % to 0·60 %, and the copper from 0 to 4·51 %. It was only with the highest copper content mentioned that red-shortness occurred in forging. With copper up to 0·85 % the steels welded satisfactorily. The addition of copper appears to have eliminated the sulphur markedly; there was 0·038 % in the ingot with no copper and 0·02 % sulphur in the ingot with 4·51 % copper. With 0·85 % copper the segregation of Cu towards the bottom of the ingot begins to be noticeable, and this increases with the Cu-content. Up to 0·49 % Cu markedly decreases the rate of corrosion in dilute sulphuric acid, but with higher Cu the rate of corrosion becomes greater than when Cu is absent. With increase of Cu the microstructure becomes finer, said to be due to the more even distribution of the carbide. This is more particularly the case in the steels in the forged condition. The critical temperature Ar_1 is lowered by additions of Cu to 685° C. in the steel containing 4·51 % Cu. The elastic limit increases with addition of Cu up to more than double at 4·51 % Cu. The tensile strength also increases progressively, up to about 55 % increase as forged, and about 45 % increase for annealed samples. The elongation of the steels as forged falls to practically nil beyond 3·0 % Cu; in the annealed steels the elongation ranges from 20 to 14 %, including a slight increase above 2·0 % copper. The scleroscope hardness increases with Cu-content, from 28 up to 48 with 4·51 % Cu. Photomicrographs, cooling curves, and a bibliography are given. F. R.

780. *Grain-growth in Silicon Steel.* **W. E. Ruder.** (Amer. Inst. Mining Engin., Bull. 84. pp. 2805–2822, Dec., 1913.)—Grain-growth in silicon steel containing 0·05 % carbon, 0·15 % Mn, 0·038% P, 0·026 % S, and 3·24 % Si, has been studied by annealing in hydrogen at various temperatures. The results show that growth begins at about 1050° C., the rate of growth then increasing with the temperature. The max. grain-size is determined by the amount and kind of mechanical work, and not by the rate of heating and cooling. Light work produces large grains, heavy work produces fine grains. When once formed the large grains cannot be altered by any heat-treatment short of actual fusion, but can be broken up by mechanical working followed by annealing above 1020° C. The effect of cold work persists even after heating to incipient fusion. In sheets below 0·007 in. thick the grain-growth is only slight. F. C. A. H. L.

781. *Influence of Thermal Treatment on the Properties of Cold-drawn Steel.* **P. Goerens.** (Rev. de Métallurgie, 10. pp. 1337–1359, Dec., 1913.)—Soft steel of the composition 0·08 % C, 0·008 % Si, 0·056 % S, 0·059 % P, and

0·89 % Mn was drawn down by a reduction of 85 % to wires of 2·7 mm. diam. After annealing at various temperatures up to 1070° C. a study was made of the mechanical properties, flexibility, density, electrical conductivity, thermoelectric properties, rate of solution in dilute sulphuric acid, potential of solution, and the structure of the various samples. The results show that the ultimate strength is sensibly lowered by heating to 100° C. but at 520° C. there is a sudden decrease of strength and a sudden increase in the elongation and contraction. Time is not so important as temperature, but nevertheless its effect increases with the temperature. A long heating at a low temperature does not have the same effect as a short heating at a high temperature. Most of the properties undergo a sudden change at or about 520° C.: the flexibility and density increase while the remanence curve shows a fairly sharp maximum at this temperature. There is also a change in the microstructure at this temperature the nerve-like structure characteristic being replaced by a granular configuration. The conclusions to be drawn from this work are that 520° C. is to be regarded as the limit between cold and hot work. Further, it is not necessary to heat the metal to the temperature of the allotropic changes to remove the effects of cold-working. A short heating at 520° C. restores the metal to its normal state, which renders possible a low fuel consumption and obviates actions detrimental to the quality of the metal, such as oxidation, decarburisation, and so on. F. C. A. H. L.

782. *Calorimetric Study of the Iron-Carbon System.* **A. Meuthen.** (Ferrum, 10. pp. 1–21, 1913. Rev. de Métallurgie, 11. pp. 19–23, Jan., 1914. Extract.) —Although a large number of researches have been carried out to determine the temperatures of the critical changes in the iron-carbon system, little work has been done on the amount of heat exchanged during the reactions which occur. An attempt has been made by the author to fill this gap by series of calorimetric determinations between 950° and 650° C. on 12 fairly pure Fe-C alloys containing 0·06 to 4·08 % carbon. The experiments were carried out in Oberhoffer's original apparatus [Abstract No. 1541 (1908)], consisting of a vacuum electric resistance furnace combined with a Bunsen ice-calorimeter. In the case of materials heated to above 710° C. care was taken to ensure the conversion of the whole of the pearlite into solid solution, and that the cooling in the calorimeter was slow enough to permit of the complete conversion into pearlite was proved by subsequent microscopic examination. Consideration of the results shows that pearlite contains 0·9 % carbon and that its heat of conversion is 15·9 gm.-cals. per gm. at 710° C. The conversion of 1 gm. β to α iron is accompanied by the development of 5·6 gm.-cals., while the separation of 1 gm. α iron from the solid solution gives out 14·1 gm.-cals. Between 650 and 700° C. the heat contents of Fe-C alloys do not show a direct linear relationship with the carbon-content. The concentration-heat curve consists of two straight lines meeting to form a maximum at about 0·97 % carbon. This may bear some relationship to the discontinuity in the specific volume curve observed by Benedicks at 1·26 % carbon, but further experiments at lower temperatures are required to explain this apparently anomalous behaviour which appears to be similar to anomalies observed in the specific heats of Bi-Sn and Bi-Pb alloys. F. C. A. H. L.

783. *Effect of Light on the Electrical Charge of Suspended Particles.* **S. W Young** and **L. W. Pingree.** (Journ. Phys. Chem. 17. pp. 657–674, Nov., 1913.)—All the suspensions, emulsions, and colloidal solutions investigated by the authors show a very distinct light-sensitiveness with respect to their rates of migration in the electrical potential gradient, the effect being positive in some cases and negative in others. This effect is readily explainable in either of two ways: (1) The influence of light is to affect the degree of dispersion of the suspended matter, increasing it in the case of acceleration and decreasing it in the case of retardation; (2) the influence of light is a direct one on the static charge carried by the suspended particles, increasing this charge in case of acceleration and reducing it in case of retardation. Since the velocity of migration of bacteria—the degree of dispersion of which can hardly be regarded as alterable—is diminished by illumination, the second explanation seems to be the correct one. T. H. P.

784. *Kohlrausch's Law of Additivity.* **G. Boizard.** (Journ. de Physique, 3. Ser. 5. pp. 701–705, Sept., 1913.)—In consequence of the results obtained by Noyes [Abstract No. 1523 (1908)], Gorke [Abstract No. 1199 (1908)], and Jones and White [Abstract No. 1789 (1910)], the author has modified certain of the values of the equivalent conductivities of the ions in solutions of infinite dilution given by Kohlrausch and Steinwehr [Abstract No. 2290 (1902)] and by Kohlrausch and Grüneisen (Preuss. Akad. Wiss. Berlin, Ber., 1904). The experimental numbers obtained for the conductivities of a large number of electrolytes are then compared with the values calculated from the corresponding ionic conductivities according to Kohlrausch's law of additivity. With strontium chloride the divergence is 1·9 per cent., and with potassium acetate 1·2 per cent., but apart from these cases the chlorides, nitrates, and sulphates, and also sodium and potassium salts, show agreement in every instance to within ± 0·5 per cent. The least concordant series is that of the acetates, with which the accuracy does not exceed 2 per cent. The value for the hydroxyl ion in c.g.s. units at 18° is $170 \times 10^{-9} \pm 1$ per cent., and that for the hydrogen ion $315 \times 10^{-9} \pm 1$ per cent. [See also Drucker, Abstract No. 1605 (1907).] T. H. P.

785. *Concentration and Conductance of Ionised Substances in Various Solvents.* **C. A. Kraus** and **W. C. Bray.** (Amer. Chem. Soc., Journ. 35. pp. 1315–1434, Oct., 1913.)—The relation between concentration and conductance may be expressed by the equation—$c(\gamma)^2/c(1-\gamma) = K + D(c\gamma)^m$, where c is the concentration, γ the conductance-ratio Λ/Λ_0, and K, D, and m are constants. In sufficiently dilute solutions the term $(c\gamma)^m$ become negligible in comparison with K, and the equation approaches the simple mass-law action as a limit. In concentrated solutions K becomes negligible in comparison with $D(c\gamma)^m$, and the equation becomes that of Storch. For $m > 1$ the molecular conductance passes through a minimum; for $m < 1$ it decreases continuously with increasing concentration. The constants of the equation may be evaluated by graphical methods. It applies not merely to aqueous solutions, but also to the extensive data for solutions in liquid ammonia.

A method is described for testing the law of mass-action without assuming a value for Λ_0. Deviations, in the case of liquid ammonia, become appreciable at ion-concentrations from 0·001 to 0·0001 normal; therefore the smaller the ionisation the higher the total concentration up to which the law is obeyed. The equation can also be applied to solutions in sulphur dioxide. The influence of temperature can be accounted for by variations in the constants.

In the case of strong electrolytes in non-aqueous solvents (including the higher alcohols) the law of mass-action applies up to ion-concentrations 0·0001 to 0·001 normal, the limit being approximately the same for a given electrolyte in different solvents and for different electrolytes in the same solvent.

In concentrated solutions in solvents of low ionising power, $1 - \gamma$ is nearly equal to unity and varies slowly in comparison with γ. This leads to the simplified equation, $c\Lambda^2 = P(c\Lambda)^m$, where P is a constant involving Λ_0. It has been found to hold good for all cases (67 solutions and 12 solvents) for which reliable data exist.

Coming now to aqueous solutions, the equation expresses the conductance of KCl between 0·001 and 2·0 normal within 0·1 per cent., but in the more dilute solutions it is necessary to assume $\Lambda_0 = 128{\cdot}8$ instead of 130·1. The accepted values of Λ_0 are probably all 1 to 2 per cent. too high, as they have been determined by extrapolation by means of an arbitrary dilution-law.

As regards the constants in the equation—with decreasing dielectric constant, K approaches zero (or a very small value), D approaches a constant value (0·85), which changes little as the dielectric constant falls below 22, and *m* increases to a value greater than 2. The marked conductance of concentrated solutions in solvents of low dielectric constant is due to the large value of D.

To sum up: all solutions of all binary electrolytes obey the same law; the mass-action law is obeyed at high dilutions; the divergence at higher concentrations is a function of the ion-concentration, and is to be attributed to the interacting forces produced by charge particles (ions) in the solution; for a given electrolyte the trend of the conductance-curve is determined by the dielectric constant of the solvent. Finally Arrhenius' method of measuring ionisation by the conductance ratio Λ/Λ_0 is valid even in concentrated solutions, beyond normal if the influence of viscosity is taken into account.

T. M. L.

786. *Chemical Reactions and Electrical Conductivity in Non-aqueous Solutions.* **H. P. Cady** and **H. O. Lichtenwalter.** (Amer. Chem. Soc., Journ. 35. pp. 1434–1440, Oct., 1913.)—Kahlenberg has suggested that instantaneous reactions between hydrogen chloride and solutions of copper, nickel, and cobalt oleates in benzene occur without conductivity or ionisation, and in defiance of the theory of electrolytic dissociation. Analogous experiments are now described with a series of very carefully-dried solutions and carefully-dried hydrogen chloride.

Copper oleate dissolved in toluene and lead erucate in benzene (both salts containing *one* double-bond) at once produced a great deflection of the galvanometer; addition of hydrogen chloride produced further great increased conductivity followed by precipitation of copper or lead chloride and a disappearance of the conductivity. On the other hand, the salts of two saturated acids, lead stearate in toluene and copper and silver melissates in benzene, produced some conductivity, increased by hydrogen chloride, but gave no precipitate. Barium linoleate (containing two double-bonds) dissolved in benzene behaved like the other unsaturated acids.

In no case was the reaction instantaneous. It is suggested that the reactions with unsaturated acids involve (1) addition of hydrogen chloride, and (2) molecular rearrangement with formation of the metallic chloride and free acid: this could not occur with the saturated salts. It is claimed that all these observations are in agreement with the theory of electrolytic dissociation.

T. M. L.

787. *Kinetic Energy of Particles in Colloidal Solution.* **A. Westgren.** (Ark. för Mat. Astron. och Fysik, Stockholm, 9. No. 5. pp. 1–36, 1913.)—The influence of polydispersivity of a sol on the distribution of its particles in the case of sedimentation equilibrium is investigated theoretically, the impossibility of an exponential relation of the concentration to the magnitude of the polydispersivity being proved. The results previously obtained by Svedberg, Inouye, and the author on the compressibility of disperse systems were made use of to calculate the distribution of the particles of a sol; if such results are correct, the distribution must differ considerably from the exponential relation. But the distribution curves now obtained with virtually monodisperse selenium and gold sols are distinctly exponential in character, so that the results referred to above must be regarded as inaccurate. The compressibility determined by the variations of concentration with time within an optically limited volume are then only apparent, and the deviations from the compressibility to be expected if Boyle's law holds are due to hydrodynamic effects. T. H. P.

788. *Surface Tension and Hydration in Solution.* **M. Padoa** and **G. Tabellini.** (Accad. Lincei, Atti, 23. pp. 88–94, Jan. 18, 1914.)—To the study of hydration in solution the authors have applied measurements of the surface tension, and more especially its temperature-coefficient, which has been shown by Eötvös to depend on the degree of polymerisation of the solvent. The surface tension has been measured by Morgan and Higgins' method of determining the weight of the drop falling from the end of a glass tube of definite dimensions [Abstract No. 1519 (1908)]. Solutions of various concentrations of ammonium chloride, cobalt chloride, sodium bromide, magnesium chloride, and hydrochloric acid were examined at different temperatures. With hydrochloric acid solutions, exceptionally low values were obtained for the Eötvös constant, and the author concludes that hydrates of hydrogen chloride are formed. T. H. P.

789. *Polarisation Capacity of an Electrode under an Alternating E.M.F. and a Method of determining it.* **P. Vaillant.** (Comptes Rendus, 157. pp. 1141–1143, Dec. 8, 1913.)—Under an alternating e.m.f. less than the limit for polarisation a voltameter may be regarded as consisting of two capacities in series. The author has made experiments to determine the capacity of a voltameter containing a (nearly) normal solution of sodium chloride in water, using Pt-wire electrodes. The method adopted was a null one in which a Curie electrometer was used as indicator, the capacity under observation being obtained in terms of three others of known value, two of which were variable. Using Pt-wire electrodes of 0·1 mm. diam., placed at a fraction of a mm. from each other, it was found that starting with a small e.m.f. and gradually increasing it, the capacity diminished at first, passed through a minimum at about 0·15 volt, and then increased nearly linearly up to 1·2 volts. For a pressure of 1·74 volts the capacity becomes infinite. For an effective pressure of 0·5 volt between an electrode and the electrolyte the capacity is of the order of 10 mfd. per mm.^{2} area of electrode. W. C. S. P.

790. *Nickeling of Aluminium.* **J. Canac** and **E. Tassilly.** (Comptes Rendus, 158. pp. 119–121, Jan. 12, 1914.)—The aluminium is immersed in a bath of boiling potash solution, then brushed with milk of lime and left for some minutes in a 0·2 per cent. potassium cyanide solution, each of these

treatments being followed by thorough washing with water. The metal is next left in a bath composed of 500 c.cm. of water, 500 gm. of hydrochloric acid and 1 gm. of iron until it assumes a "watered" appearance. It is then ready to receive an electrolytic deposit of nickel, the chloride giving a better bath than the sulphate. The coating thus obtained has a matt white appearance and can be readily polished with a scratch-brush, while it can be hammered without cracking, and can be heated to the melting-point of Al without separating from the latter. Comparative measurements of the magnetic susceptibilities of the Al before and after treatment with the iron bath show that the amount of iron deposited is very small, Féry's spectrophotometer giving from 0·25 to 0·50 gm. of iron per sq. metre. Microscopic examination reveals the existence of numerous pits in which the nickel is fixed during the subsequent electrolysis. The nickeled aluminium does not change in moist air and resists the action of dilute soda solution, glacial acetic acid or concentrated sodium chloride solution, either hot or cold. It shows no Kelvin-effect, but the coefficient of expansion of the Al is lowered by nickeling. T. H. P.

791. *Fine-meshed Brass Gauze as a Substitute for Platinum in Electro-analysis.* **D. F. Calhane** and **T. C. Wheaton.** (Metallurgical and Chem. Engin. 12. pp. 87–89, Feb., 1914.)—Brass wire gauze (100 meshes per linear inch) has been used by the authors, over a period of two years, in the electrolytic estimation of copper, zinc, and nickel. The kathode used was made from a piece of gauze, 5¼ in. by 3¼ in., the longer edges of which were lapped over and hammered down, and the shorter ones bent over a 12-in. loop of copper wire (22-gauge) the ends of which were afterwards twisted together. The cylinder thus formed was thinly plated with copper, then washed, dipped in alcohol, dried and weighed for use. The anode consisted of a spiral made from 10–12 in. of platinum wire weighing about 1 gm. In the case of ammoniacal solutions, the copper wire stem of the kathode had an insert of Pt-wire, two pieces of which, each 3 in. long, were attached to the gauze, twisted together, and so joined to the stem. Brass gauze could not be used in the separation of silver from copper in cyanide solution, as the zinc dissolved and silver was deposited; but in all successful cases the efficiency of the brass was equal to that of Pt-gauze, the time factor for the former with still electrolyte being nearly as good as that for the latter with magnetic stirring. Details are given of the procedure followed in the electro-analysis of copper scale and various alloys of nickel, copper, and zinc. T. S. P.

792. *Electrolysis of Aqueous Solutions of the Simple Alkaline Cyanides.* **G. H. Clevenger** and **M. L. Hall.** (Amer. Electrochem. Soc., Trans. 24. pp. 271–289; Discussion, pp. 289–296, 1913.)—As a result of their experiments the authors come to the conclusion that the bulk of the decomposition of cyanide occurring during electrolysis is due to oxygen liberated at the anode through the decomposition of water. The principal final reaction in solutions containing protective alkalinity, which in cyanide-mill practice is usually due to lime, is the formation of the corresponding alkali carbonate, this accounting for the formation of large amounts of calcium carbonate during the electrolytic precipitation of gold and silver from cyanide solutions. T. S. P.

793. *Electrolysis of Cyanide Solutions.* **E. F. Kern.** (Amer. Electrochem. Soc., Trans. 24. pp. 241–265; Discussion, pp. 265–270, 1913.)—The electrolysis of cyanide solutions by direct current, using insoluble anodes, is accompanied by progressive consumption of cyanide, which is oxidised to oxy-cyanide compounds. Anodes of iron, nickel, and lead are dissolved during such electrolyses, the lead then being precipitated as hydroxide and the iron and nickel as a mixture of hydroxide and cyanide compounds. Using these attackable electrodes, the consumption of cyanide is relatively greater the lower the current density, since with high current densities oxygen is also liberated and, consequently, less metal dissolved. The consumption of cyanide is less with lead than with iron or nickel anodes. Peroxidised lead and "passive" iron anodes are more permanent than anodes of either iron, nickel, or lead, the "passive" iron anodes giving the best results. When the cyanide solutions contain sulphocyanides or ferrocyanides, the cyanide consumption is much less than with pure cyanide solutions; the consumption is also diminished by increased alkalinity of the solutions. The lower the current density at the anode and the higher it is at the kathode, the greater relatively is the cyanide consumption. The electrolysis of cyanide leach solution was not found to be beneficial in commercial operations, either in reducing the cyanide consumption or in increasing the percentage extraction. T. S. P.

794. *Solid, Thick Deposits of Lead from Lead Acetate Solutions.* **F. C. Mathers.** (Amer. Electrochem. Soc., Trans. 24. pp. 315–329, 1913.)—The author has investigated the electro-deposition of lead from various solutions of lead acetate, and shows that, if the proper addition agents are introduced, solid, dense, coherent deposits can be obtained, thus disproving the statement of Betts that "no good deposit has ever been obtained when the basis of the electrolyte is a weakly-dissociating acid." The addition agents were both inorganic and organic, and photographs of the deposits are given. It is probable that any soluble lead salt will give dense, coherent deposits if the proper addition agents are used. [See Abstract No. 2018 (1913).] T. S. P.

795. *Simultaneous Determination of Copper and Lead with the Rotating Anode.* **A. J. White.** (Amer. Electrochem. Soc., Trans. 24. pp. 297–303; Discussion and Communications, pp. 303–306, 1913.)—The author finds that when less than 0·15 gm. of lead is present with 0·60 gm. of copper, the two metals are quantitatively deposited from a sulphuric-nitric acid solution in 80 mins. by a current of 8 amps. at 6 volts. The best proportions of acid are 4 c.cm. of concentrated nitric acid and 10 drops of concentrated sulphuric acid in a volume of 70 or 80 c.cm. A rotating, roughened dish anode is used to deposit the lead dioxide on, the kathode also being a Pt-dish. The application of the method to the analysis of brass and other alloys is described. [See Abstract No. 1916 (1913).] T. S. P.